Volume 31. DECEMBER, 1917. $3.00 a Year.
Number 4. $1.00 a Number.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION,

715 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

Copyright, 1917, by the NEW ENGLAND WATER WORKS ASSOCIATION.

OFFICERS

OF THE

New England Water Works Association.

1917.

PRESIDENT.

CALEB M. SAVILLE, Chf. Engr., Bd. Water Commissioners, Hartford, Conn.

VICE-PRESIDENTS.

CARLETON E. DAVIS, Chief, Bureau of Water, Philadelphia, Pa.
SAMUEL E. KILLAM, Supt. Pipe Lines and Reservoirs, Metropolitan Water Works, Boston, Mass.
HENRY V. MACKSEY, Supt. of Public Works, Woburn, Mass.
FRANK A. BARBOUR, Consulting Hydraulic and Sanitary Engr., Boston, Mass.
PERCY R. SANDERS, Supt. Water Works, Concord, N. H.
THOMAS MCKENZIE, Supt. Water Works, Westerly, R. I.

SECRETARY.

WILLARD KENT, Civil Engineer, Narragansett Pier, R. I.

EDITOR.

HENRY A. SYMONDS, Civil Engineer, 70 Kilby Street, Boston, Mass.

TREASURER.

LEWIS M. BANCROFT, Supt. Water Works, Reading, Mass.

ADVERTISING AGENT.

GEORGE A. KING, Supt. Water Works, Taunton, Mass.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

WILLIAM F. SULLIVAN, Engr. and Supt. Pennichuck Water Works, Nashua, N. H.
FRANK J. GIFFORD, Dedham, Mass.
A. R. HATHAWAY, Water Registrar, Springfield, Mass.

FINANCE COMMITTEE.

EDWARD D. ELDREDGE, Supt. Onset Water Co., Onset, Mass.
A. E. PICKUP, Water Registrar, City of Holyoke, Mass.
BERTRAM BREWER, Supt. of Sewers and Water Works, Waltham, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of about **1 000** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

Table of Contents.

	PAGE
Address of President at Annual Convention	545
The Regulation of Private Water Companies in New York City. By Delos F. Wilcox	550
Hartford Water Works, Past and Present. By W. E. Johnson	575
Hartford's Distribution System. By Frank Brainard	581
Engineering on the Additional Water Supply for the City of Hartford. By H. W. Horne	588
The Design of Diversion Conduit and Waste Works of Richards Corner Dam at New Hartford, Conn. By R. E. Wise	595
The Construction of Nepaug Dam. By H. W. Griswold	603
Grouting of Rock Foundations of the Dams of the Additional Water Supply of the City of Hartford. By J. E. Garrett	609
Care and Operation of Mechanical Rapid Sand Filtration Plant. By John W. Gaitenby	619
Some Aspects of Stream Pollution in Connecticut. By J. Frederick Jackson	627
Some Operating Problems of a Small Water Department. By Homer R. Turner	633
Proceedings:	
June, 1917, Meeting	642
November, 1917, Meeting	644
Presentation of Dexter Brackett Memorial Medal,	648
Report of Committee on Exhibits	650
December, 1917, Meeting	656
Report of Committee on Finance	658
Executive Committee:	
June 13, 1917	671
November 14, 1917	671
December 12, 1917	673

New England Water Works Association.

ORGANIZED 1882.

Vol. XXXI. December, 1917. No. 4.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

PRESIDENT'S ADDRESS AT ANNUAL CONVENTION, SEPTEMBER 10, 1917.

Gentlemen of the New England Water Works Association, — You have heard the speakers who have preceded and you have listened to the greeting that Hartford extends to the New England Water Works Association.

A very able diplomat is alleged to have stated that "language was given man to conceal thought." From my personal and official contact with these gentlemen and those whom they represent, I can assure you that Talleyrand's thought does not apply to the people of Hartford.

Gentlemen of the city of Hartford, in the name of the New England Water Works Association it gives me the greatest pleasure to thank you for your kind words, for the cordial welcome you have extended, and for the hospitality which you have indicated to be your purpose to show us during our stay in Hartford.

In starting out on our convention program, a few words may not be amiss as to the aims and objects leading up to this meeting.

The New England Water Works Association is a "get-together" organization of men whose principal business is connected with supplying water. Included in our membership are specialists in various matters of water supply, water-works operators who are doing the practical, every-day work, and manufacturers of water-works equipment who provide the materials we use in our work. Each of us is here to help the other and by so doing help the public whom we serve. Men from all parts of the world are on the rolls

of this Association, and to those who know its beginnings and its traditions there is a very deep personal interest in its life and future.

The matter of supplying water is of a different character from that of any other municipal industry. All others primarily are disbursing agencies handling allotted funds. Their principal duties are to see that their funds are honestly and economically expended on predetermined work.

The water department, on the other hand, is always a commercial enterprise, similar in many of its requirements to other public utilities, as, for example, the business of furnishing light and power by gas or electricity and the running of steam and electric railways. Here there is a question both of production and distribution, with new problems continually arising as to methods of operation and maintenance. Economical and efficient means must be employed to produce an article that will satisfy customers and be delivered to them at fair rates. The plant must be operated in such a manner as to be at least self-supporting. Thousands of consumers must be handled individually with the same regard as obtains in the best conducted retail trade. The demands of a modern water-supply system are complex and are concerned with matters little dreamed of a generation ago.

The men who are efficiently handling this work to-day are trained, practical men, skilled in their professional work, single-eyed to economical administration, and alert to recognize, seize, and apply the latest developments in water-works science.

To-day something more is required of the water-works executive than to be able to get four hundred eighty minutes' work for the price of labor, properly to lay pipe, and quickly to repair a break in a supply main. These things are necessary in carrying on department work, but they are not the essentials of present-day management. The water-works executive must be familiar with all of these, but in addition he must have intimate knowledge of and ability to handle such financial questions as valuation of works and equitable rate making, as well as hydraulic problems relating to supply and construction or the complex questions involved in providing a water which satisfies modern standards.

Intelligent systems of accounting are necessary. Rules and regulations adjusted to present conditions are required. Scientific purchase of materials and supplies, cost keeping that instructs, modern transportation, checks on the care of department property, and similar matters, are all part of the organization of even the mediocre construction company. How can water department business succeed without them? The question of revision of rates to meet existing conditions is most vital to successful operation, but one which is often the last to be taken up, particularly in municipally operated plants.

Many rate schedules now in use even in our larger cities are inheritances of the past, continued because of the inertia of the present. Some of these are ridiculously inadequate and fail utterly to recognize conditions of plant, cost of operation, and special value to different classes of users. Such conditions result in extravagant operation and in ineffectual service.

At the present time it is the trend of opinion, based on judgment of the best sanitary specialists, that all public water supplies sooner or later must be filtered. Water is demanded which is clean and attractive as well as that which is safe. These questions involve protection from pollution, removal of turbidity and color, reduction of chemical constituents producing hardness and other detrimental conditions, and the elimination of taste and odor.

These are some of the problems of the modern water-works executive. Properly met, they mean efficiency in organization and economy in operation, with consequent benefit to the city. To do these things it is necessary that the manager of the water department shall be able to grasp, understand, and control adverse conditions which were formerly accepted as inevitable but are now known to be amenable to remedy if not to cure.

The past experience of this Association with its avoidance of entangling alliances is the best guide we can have for the future. Our present position as a power in water-department matters shows clearly the wisdom of the founders of this Association in rigidly excluding both politics and commercial exploitation from its voting membership. "As with the fathers, so may God be with us."

With other organizations we will work together gladly, and we welcome all water-works men to our membership.

Careful consideration of our own particular needs and purposes, however, forbids any thought of combination with others.

In these critical and serious times it is well for us to cultivate the attitude of the open mind and the spirit of coöperation.

One of the most cogent reasons why our manufactured products, up to the war period, had so little market in Central and South America was the arbitrary stand of American producers as to details of construction and methods of packing goods, regardless of the needs of the purchaser.

Until many of our manufacturers and consumers, on the one hand, emerge from this attitude of pigheadedness, and on the other step aside from a position of cocksureness, there will be difficulty in meeting the demands of commercial enterprise and construction possibility. Opportunity is hindered by ignorance and the effect of the small mind, unable to comprehend the standpoint of the other fellow. The talisman of success is "coöperation." Manufacturers must concede the necessity and be willing to consider with open mind changes in plant, even though expensive to them, if efficiency and economy result in construction work.

Engineers and users of manufactured products must recognize business exigencies and matters affecting established industry. They too must have the open mind which is free from personal bias, broad in its outlook, and dispossessed of a finicky attitude. In the "get-together" atmosphere of this convention let us all try to get into touch with the real reasons for the differences between users and producers and see if we cannot reach some mutually advantageous ground in advance of that on which we now stand.

In these days the direction of the force of gravity as regards cost of labor and materials appears to have been reversed. An efficient way, and perhaps the best way, to meet this condition seems now to be the more general use of labor-saving tools, careful selection of materials, more thoughtful planning of work, and better organization of force. Present prices of labor and materials in many cases are beyond that ever before experienced, and the outlook into the future seems to reveal little or no downward

tendency. For a short period there seemed to be a faltering in construction work, but contract news, construction advertisements, and bond sales indicate recovery, with a tendency to accept present prices as better perhaps than will be afforded later. From this viewpoint, more and more public work of considerable magnitude is being let. With the reduction of labor due to national requirements and the possibility of greater demands for materials, even if peace should come quickly, there seems to be greater chance for increasing cost of work for some time to come.

To consider these problems, gentlemen, is the reason we are in convention at Hartford this week. While we sincerely appreciate and shall heartily partake of all the hospitality and the entertainments offered, business, more perhaps than ever before, should take precedence. For this purpose we are to listen to papers presented by sanitary engineers skilled in special lines, by practical water-works operators who are doing things worth while on their own water-works departments, and by makers of appurtenances used and necessary in water-department work. Valuable as are these papers, more useful yet is the discussion which should arise. Special practical problems are welcomed for solution, for questions that perplex one are sure also to have troubled many others.

Gentlemen, the convention is now open. Gain what you can from the store of instruction which is yours for the taking, and enjoy to the utmost Hartford's bountiful hospitality.

THE REGULATION OF PRIVATE WATER COMPANIES IN NEW YORK CITY.

BY DELOS F. WILCOX, PH.D., DEPUTY COMMISSIONER OF WATER SUPPLY, GAS, AND ELECTRICITY, CITY OF NEW YORK.

[*An address before the New England Water Works Association, at Hartford, Conn., September 12, 1917.*]

New York City claims the distinction of having the largest municipal water plant in the world. It has already invested $360 000 000 in water works, and is still going on with the development of its supply. It now furnishes water at the rate of about 550 000 000 gallons per day to a population of over 5 000 000 people and has a total dependable supply of between 700 000 000 and 800 000 000 gallons per day. Although it is an "unmetered town," and although the commissioner of water supply has thus far been unable to secure the legal authority to require the installation of meters in residential premises, nevertheless there were, on June 30, 1917, 104 357 meters in service. I suppose that New York City's municipal water works constitute the largest experiment in municipal ownership and operation existing anywhere in the world.

The magnitude of the problems growing out of the construction and operation of this water plant has had the effect of distracting attention from the operations of the private water companies still serving portions of the metropolis, and of obscuring their relations to the city government. The fact is that five important water companies that enjoy public franchises are still operating within the limits of Greater New York. Indeed, about one fourth of the city's area, and 400 000 of its population, are at the present time dependent directly upon the private companies for both domestic service and public fire protection. Besides the five larger companies which are operating in their respective territories without any appreciable competition from the municipal water plant, another company of considerable magnitude, operating under easements obtained before the streets were opened to

the public, is serving a considerable population in direct competition with the city plant, and still another company, operating under a public franchise, offers a small but annoying problem of competition to one of the larger companies. An area of 85 square miles and a population of 400 000 would, in most localities, constitute a large city, and the water problem of such a city would be very much more complicated than that of most cities if, instead of being served by a single plant, it was served by seven different plants owned and operated independently of each other.

In the city of New York the Department of Water Supply, Gas, and Electricity combines, under the jurisdiction of a single commissioner, the operation of the municipal water works; the supervision of the private water companies; the provision of street and public building lighting through contracts with private corporations; the control of the subsurface structures of gas, electrical, telephone, and steam heating companies; electrical inspection, and certain minor functions of municipal government. For the purposes of this paper we may neglect all of these miscellaneous functions which do not have a direct relation to the water service. It is necessary, however, to describe in brief outline what the commissioner's powers are in relation to the municipal water works in order to give the proper perspective to the problems arising out of his exercise of supervisory control over the private water companies.

The major portions of the municipal water-works plant, other than the distribution system, have been constructed from time to time by separate agencies such as the Croton Aqueduct Board and the Board of Water Supply, but the commissioner's jurisdiction over all water-works structures when they come into use as a part of the municipal plant is complete. It is also his duty to look out for the city's needs and select new sources of water supply, which, with the approval of the Board of Estimate and Apportionment and the Board of Aldermen, may be taken by condemnation proceedings anywhere within the state of New York, provided they are not already in use, or reasonably necessary for the future use of some other municipality. The commissioner also has jurisdiction over the construction and extension of the distribution system and pumping stations and other local facilities in

connection with the operation and development of the water plant. The money for all construction work is obtained through the issuance of municipal bonds, and the comissioner is powerless to use the revenues derived from the sale of water for extensions to the distribution system. Thus his discretion in construction matters is strictly limited by the financial control exercised by the Board of Estimate and Apportionment, whose approval is necessary for the issuance of bonds for water purposes.

In respect to the relations of the water department to the consumers, the commissioner's powers are described and limited by the provisions of the Greater New York charter and the code of ordinances. In the establishment of rates and charges, his action is subject to approval by the Board of Aldermen, but the water rents, based upon the rates and charges so fixed, are, by charter, made a lien upon the premises where the water is supplied, and the times for the payment of water rents and the penalties imposed for failure to pay promptly are also fixed by the charter. The commissioner is authorized, in his discretion, to cause water meters to be installed in all places where water is furnished for business consumption, but he has no power to require their installation in residential premises unless authorized to do so by the Board of Aldermen. Individual property owners, however, may at will demand the installation of meters on their services, whether the water is used for domestic or for business purposes. The commissioner has a wide latitude in the establishment of rules and regulations for the control and operation of the municipal water works, but, of course, such rules and regulations must fall within the limitations laid down by the charter and the ordinances. In practice, New York City requires the consumer to install and maintain the service pipe, and also the meter wherever the use of the latter is authorized. Theoretically, the commissioner can establish rules by which the purchase, installation, and maintenance of meters and service pipes would be assumed as a department function, but under existing restrictions of law and ordinance the expense in both cases would have to be charged against the property owners. Moreover, the commissioner's financial restrictions are such that it may at times be impracticable for him to make a radical change in the procedure of the water

department in matters of this sort without having secured in advance from the financial authorities of the city the appropriations necessary to carry them out. The revenues from the sale of water are not available for use by the commissioner in the operation of the department except to the extent that specific provision has been made therefor in the appropriations.

I refer to these matters for the purpose of showing the limitations imposed by legal and financial conditions upon the commissioner's discretion in regard to the operation of the municipal water plant, as contrasted with the absence of such limitations upon his control over the operations of the private water companies now to be described.

Private water companies in the state of New York are organized under the transportation corporations law, and, in the absence of special charter provisions governing the granting of franchises, they have usually secured perpetual rights by the simple process of applying in advance to the local authorities for permission to organize for the purpose of supplying the community with pure and wholesome water. Neither private water companies nor municipal water plants have thus far been brought under the jurisdiction of the public service commissions of the state, and thus no general machinery has been provided for the control of their rates and service. They are subject to the State Health Department in matters relating to pollution and to the State Conservation Commission with respect to the acquisition and development of additional supplies.

Within the limits of Greater New York the absence of effective state control over the rates and practices of these companies is made up for, in part, by a provision of the charter giving to the commissioner having charge of the municipal water works, power over the operations of the private companies, of which the municipal plant is a potential or, it may be, an actual competitor. Section 472 of the charter authorizes the commissioner " to examine into the sources of water supply of any private companies supplying the city of New York or any portion thereof or its inhabitants with water to see that the same is wholesome and that the supply is adequate, and to establish such rules and regulations in respect thereof as are reasonable and necessary for the convenience of the

public and the citizens." It also provides that the commissioner "may exercise superintendence, regulation, and control in respect of the supply of water by such water companies, including rates, fares, and charges to be made therefor, except that such rates, fares, and charges shall not, without the consent of the grantee, be reduced by the said commissioner beyond what is just and reasonable." It is further provided that "in case of a controversy, the question of what is just and reasonable shall be finally determined as a judicial question on its merits by a court of competent jurisdiction."

This is the public service law applied to private water companies in the city of New York. The use of the word "fares" with relation to the charges of a water company suggests that this provision of the law was "lifted" from some other statute, which had relation to street railway companies. Perhaps the astute legislators figured that inasmuch as a water company has to be incorporated under the transportation corporations law, it could with entire propriety charge "fares" for its water. The use of the word "grantee" in the provision relating to the company's acceptance of a regulation of rates promulgated by the commissioner also bears the earmarks of extraneous origin. This word seems to connote a condition applicable where rates are being fixed in connection with the granting of a franchise, although the commissioner has no franchise-granting powers whatever.

In addition to the verbal peculiarities just noted, this regulatory law presents a number of rather unique features. In the first place, it is very broad and general in its language, keeping as far as possible away from the minute and involved details incorporated in the public service commissions law of New York, and in similar laws of other states. This has the result of leaving both the commissioner and the companies in the dark as to the precise extent of his jurisdiction over them, and in the absence, during a period of nearly twenty years, of any serious litigation affecting the commissioner's powers, they have remained in a happy condition of uncertainty. We sometimes read that operations on the European battlefront are temporarily suspended on account of fog. I should not care to be called upon to guess whether the continued fog enveloping the commissioner's authority over the

private water companies was responsible for the absence of more active operations on this particular war-front during the sixteen years prior to 1914, or whether the spirit of coöperation between the water department and the private companies during this period was so cordial that the presence of the fog was in no way embarrassing to them. Only recently, litigation has been started to test the commissioner's right to compel the private companies to install water main extensions. In this case the company "took first blood," as the judge in the lower court held that the broad, general language of the statute does not give the commissioner authority to require a private company to extend its mains. The case is being appealed, and it is hoped that through the smooth-moving processes of adjudication the commissioner's powers with respect to extensions will ultimately be defined and established upon a solid foundation.

[The decision of the lower court has just been reversed (December 8, 1917) by the Appellate Division, in an opinion fully sustaining the commissioner's authority to require a private water company to extend its distributing mains.]

The second point of interest in our regulatory law is the absence of any limitation upon the commissioner's powers with respect to the fixing of absolute as distinguished from maximum rates. Under the public service commissions law of New York, the rates fixed by public authority are maximum rates, while in Wisconsin, California, and some other jurisdictions the commissions have been given specific authority to fix absolute rates. It is of considerable importance to the commissioner that his control over the charges of the private water companies should be such as to enable him to fix absolute rates, especially in view of the existence of competitive conditions with respect to the water service in certain areas. It is clear that under conditions of actual or potential competition the power to fix absolute rates is an essential factor in effective regulation. The commissioner's authority in respect to this matter has never been tested in court.

The third point of interest in our regulatory law is the provision that the commissioner shall not *reduce* the rates of the private companies beyond what is just and reasonable without their consent. Apparently, the authors of the law did not antici-

pate that the commissioner would encounter any serious objections from the companies if he attempted to raise their rates, and it was not considered necessary in the days when this law was drafted to provide the aggrieved consumers with any specific means of relief in such a contingency. Another issue has arisen in this connection because of the fact that the city as a municipal corporation, within the areas which the companies serve, takes water from them for street uses, for the supply of public buildings, and for fire protection. It has been the policy of the city up to the past few years to enter into contracts with the several companies for hydrant service. All such contracts, under another provision of the charter, before being executed by the commissioner, must be approved in all their details by the Board of Estimate and Apportionment and also by the mayor and the comptroller separately. Upon the expiration, a number of years ago, of the hydrant rental contracts between the city and the Queens County Water Company, it was found impossible to negotiate terms for hydrant service under a new contract acceptable to both parties, and, therefore, as the hydrant service was absolutely necessary, the company continued to render it and the city continued to pay for it without any contract. Ultimately, when the question of the revision of this company's rates to domestic consumers came before the commissioner, he found that the city was paying much less than the fair cost of the fire protection service, while the rates to private consumers were too high. The question then arose as to his power to increase the hydrant rates payable by the city, without the consent of the Board of Estimate and Apportionment or any other city authority. The commissioner was advised by the corporation counsel that his power to regulate the rates of a private water company extended not only to rates for domestic and business service, but also to rates for hydrant service and public fire protection. Acting upon this advice, the commissioner assumed the full responsibility of readjusting the rates, in the particular case to which I refer, in such a way that the financial obligations of the city, so long as it continued to accept the service from the company, would be largely increased, while the rates to domestic consumers were reduced. The company promptly accepted the rate order, but it was some

time before the Board of Estimate and Apportionment and the comptroller, constituting the financial authorities of the city, concluded to accept the new rates. The curious thing about the legal situation in this case was that the city as a consumer had no practical method of appealing from the decision of the Commissioner of Water, Supply, Gas, and Electricity acting in his capacity as an impartial regulator of water rates.

Still another point of interest in our regulatory law is the provision as to what shall happen in case of a controversy between a company and the commissioner over a proposed reduction of rates. The statute provides that in such a case the question as to what are just and reasonable rates shall be finally determined as a judicial question on its merits by a court of competent jurisdiction. While the procedure to be followed under this provision of the law has never been worked out in practice because of the fact that no litigation between the city and a private company has yet been undertaken in respect to the regulation of a company's rates, it appears from the language used that when the commissioner has rendered his decision, if the company affected refuses to accept it, the commissioner's order will be ineffective, and just and reasonable rates will not be fixed at all by public authority unless, by injunction proceedings or otherwise, either the city, or the company, or the consumers, remove the whole question to the courts, where the issue will be treated as an original one, no matter what kind of a record has been made before the commissioner. Moreover, it appears that the decision of the court, technically at least, will not be to sustain the commissioner's order, or, in case the order is found to be unjust and unreasonable, to reverse it and refer the question back to the commissioner for further consideration, but, on the contrary, the court will have to assume the responsibility of fixing the rates on the basis of evidence produced before it. This is another point of great importance that, in the absence of litigation to determine it, rests upon the insecure foundation of interpretation of law by laymen, whose judgment is often warped by the assumption that statutes, when apparently clear, mean what they say.

The exercise of the commissioner's powers of control over the private water companies is affected, equitably if not legally, by

the fact that it is the general policy of the city of New York to extend the municipal water service throughout its boundaries and to attain, so far and so soon as practicable, a monopoly of the public water service.

In view of the enormous investments which the city has made in its water works and of the general tendency toward the municipalization of public water service, it is somewhat surprising that the private water companies operating within the city limits have not been entirely eliminated long ago. These companies got their start, not in franchises granted by the present city or by the former city of Brooklyn, but in franchises granted by numerous towns and villages which were subsequently brought into the Greater City. No water franchise has been granted within the present limits of Greater New York during the past twenty years. The city has already acquired a number of private water companies, notably those which formerly operated on Staten Island, until now the operations of the private companies are practically confined to three of the five wards of the borough of Queens and two of the thirty-two wards of the borough of Brooklyn. The city's progress towards the extinguishment of these companies has no doubt been retarded in the past by the continued shortage of water available for the supply of Brooklyn and Queens, these boroughs constituting the portions of the Greater City which occupy the western end of Long Island. Indeed, this shortage was so great that for many years the city purchased large quantities of water from the company operating in the second ward of Queens for delivery into the municipal mains for distribution to the city's consumers in the first ward of that borough. All the private companies on Long Island derive their supplies from wells, and it is a physical characteristic of Long Island that a water supply can be secured from the ground in almost any location by means of an adequate well development. Local supplies for the service of restricted areas can be economically developed in comparatively small units on Long Island, and a private water company in a suitable location may be able to supply the section of the city in which it operates at a lower cost per unit than the cost to the city of developing a supply adequate for a much larger service. Pending the completion of the city's great project for

bringing an abundant supply from the Catskills, it was not altogether uneconomical, from the water supply point of view, to permit the several private companies on Long Island to continue in operation in those districts where the city had no mains. Moreover, it must be admitted in fairness to the existing companies that, as a general thing, their consumers seem to be well satisfied with the quality of the water supplied, particularly for drinking purposes, and it is not strange that people who have been accustomed to the relatively hard and cold waters supplied from the wells of Long Island should be somewhat hesitant about taking in exchange the soft surface waters from the Croton and Catskill watersheds which constitute the city's principal sources of supply.

Nevertheless, the continuous encroachment of population upon the watersheds of the companies results in a gradual lessening of the amount of water available from these sources, while at the same time the increased demand for it tends to cause an overdraft upon the wells, with a resultant increase in chlorine and hardness which makes the water less desirable, particularly for industrial and laundry purposes. Also, the possibility of pollution as the growing city flows out to encompass these water-bearing lands tends to weaken the consumer's predilection for his local supply as compared with the supply from the mountains which the city now offers. All of these factors tend to complicate the relations existing between the commissioner as a regulatory authority and the private companies.

The city is now in a position where it has surplus water to sell, and would be glad to extend its service without further delay to the areas now served by the private companies. It would be glad to purchase their distribution systems and incorporate them as a permanent part of the municipal water plant, but unfortunately a large portion of the properties of these companies consists of lands, wells, pumping machinery, and buildings which, if acquired by the city, would be of no appreciable use to it for water purposes. The city has no desire to destroy the companies' legitimate investments, and for that reason prefers not to enter the territories served by them and parallel their mains for the purpose of competing with them. But the city takes the position that its enormous expenditures for the purpose of introducing an abundant

supply of water into the metropolitan area have actually and properly had the effect of depreciating the value of the companies' plants taken as a whole, by rendering portions of them obsolete or nearly so. At the same time, the city is unwilling to permit the companies to continue to operate their private plants without regard to the demand for uniformity of rates and conditions of service throughout the city area. Some of the companies charge rates considerably higher than the city rates, and most of them tend to be much more conservative than the city would be in the layout of their distribution systems and in the quality of the fire protection rendered to the districts in which they operate. The city does not wish to disregard what it considers to be their legitimate rights, but at the same time it is unwilling to limit for their benefit its policy as to water rates and as to the development of the water service throughout the metropolitan area. In the case of some of the companies, their land holdings are an important element of their property, and it is with reference to this factor particularly that the city is unwilling to compensate them on the basis of an assumed monopoly value for sources of water supply which the city does not need.

In view of the conditions which I have outlined, the efforts of the water department during the last three or four years have been gradually quickened with respect to the supervision and regulation of these companies. The principal lines along which regulation is now being undertaken are the following:

1. The department's first duty in relation to the private water companies is to supplement the functions of the state health department and the local board of health with respect to the quality of the water supplied for domestic uses. The department maintains a laboratory at which its own water supply is subjected to continual examination as to its chemical and bacteriological contents. In like manner, samples are taken monthly from the different pumping stations of the several private companies and subjected to careful scrutiny. Whenever such examinations show indications of possible pollution, the companies are notified and special investigations are made to find out what the trouble is. These laboratory tests are also used for the purpose of determining the quality of the water with relation to such matters

as its iron content, its hardness, or the presence of obnoxious gases tending to impair its potability. In this way the department performs for the private water companies and for their consumers a fundamental service by the insistence upon high standards in relation to the purity and potability of the water supply drawn from private sources, the same as it does as to the sources which the municipality itself has developed.

2. For the purpose of securing better fire protection and more adequate domestic service in the private water territories, and especially for the purpose of seeing that their distribution systems are properly laid out and ready to be incorporated into the city's system at some future time, the department has assumed to pass upon the location and character of additions to these distribution systems. Under their franchises the companies undoubtedly have the right to open the streets in the territories served by them for the purpose of installing water mains and appurtenances, but under the provisions of the charter, before they can exercise this right, they must apply to the Department of Water Supply, Gas, and Electricity for permits to do so. The department now prepares project sheets for the various extensions which the companies desire to install or which are demanded by the private consumers or by the fire department. These projects show the size and location of the mains to be installed and the location of the hydrants. After going through the hands of the engineers of the department, these projects are presented to the commissioner for his approval. If a project is approved, one of two courses is followed. In case the company has applied for a permit to install the main, the permit is issued. In case, however, the project has been prepared by the department on its own motion, or upon the petition of property owners or of the fire department, the commissioner issues an executive order to the water company directing it to install the main and hydrants as set forth on the project sheet.

Formerly, the matter of extensions was taken care of as a part of the hydrant rental contracts in the case of several of the companies, but during the past few years, in the absence of these contracts, the companies have been getting into the habit of complying with the commissioner's directions with respect to extensions. Recently, however, the commissioner had to go to court

to seek to enforce one of his extension orders. The judge expressed the opinion, already referred to, that the commissioner has no power to require a private company to extend its mains. If this decision stands, it will nullify in a very important particular the regulatory work of the department, and in case the companies take advantage of their legal rights, this decision may make it necessary for the city to give up the policy of attempting to regulate the construction of their distribution systems and, as an alternative, adopt the policy of extending the city's mains into their territories without regard to them. It seems obvious to every careful student of public utilities that competition and regulation by executive order are for the most part mutually exclusive remedies, and where the city is in a position, as the city of New York is, except with respect to a single company, to attain its purposes by direct action without submitting to prolonged litigation for the establishment of its regulatory powers, it would seem that the private companies should in their own interest adopt a conciliatory and reasonably compliant attitude.

3. As already stated, the private companies in New York City secure their supply from wells. Long Island offers very meager facilities for storage reservoirs, and so the companies have to depend for the most part upon continuous pumping direct into their distribution systems, with the assistance of standpipes in some cases to equalize the pressure and furnish a small reserve for the draft at the peak of consumption and in case of a big fire, a breakdown, or other emergency. Under these conditions it is pretty difficult and expensive for them to supply what is really a safe and adequate reserve for fire protection. The water department, therefore, is putting into effect the policy of establishing emergency connections between the city distribution system and the private companies' systems in order to enable the city to assume in part the conflagration and emergency hazard in the private water company territories, and thereby to insure a much better service to the people in these areas than would otherwise be available to them, or a service which, if made available through additional investments by the companies, would entail upon the city much larger payments for public fire protection than are now being made. The department is thus gradually in effect consolidating

for purposes of adequate service and economy of operation the various sources of supply, both municipal and private, which are now available for use in New York City.

4. The department has to operate a miniature public service commission plant for the purpose of investigating and adjusting complaints submitted to it by the private water companies' consumers. These relate to the quality of water, extensions of mains, character of service, general practices controlled by the companies' rules and regulations, and rates. The department's policy with reference to purity and sufficiency of supply and extensions of mains has already been described. In case of specific complaints as to adequacy of service or as to a company's practices in relation to its consumers, the policy is to make such investigation as may be necessary to determine the justice of the complaint. This is done either by a personal inspection or by a reference of the complaint to the water company for a report, or by both of these methods. After the facts have been ascertained and a decision reached, the matter can usually be adjusted without the issuance of a formal order to the company.

The commissioner has the right under the provisions of the regulatory law to establish, in respect to the companies' water supply, reasonable rules and regulations necessary for the convenience of the public and the citizens. The commissioner has not as yet put into force a uniform set of rules and regulations for the control of the several companies in their operations; nor has he issued a complete set of rules and regulations for any one of the companies, although many matters of detail have been taken up in individual cases. The department finds that the preparation of a uniform set of rules and regulations for the guidance of all the companies is beset with many difficulties because of the differences in their rates and their fundamental relations to the consumers, as well as because of the fact that it is deemed inexpedient to prescribe rules and regulations requiring a different and more liberal standard of service from the private companies than the standard adopted by the city itself. I refer to such things as the ownership and maintenance of meters by the utility, a matter over which the commissioner has no final control in the case of the municipal plant. In some cases the companies are more

liberal to their consumers than it is within the water department's power to be to the consumers on the city service. The department does not wish to establish uniform rules and regulations which would compel some companies to be less liberal than they now are, and at the same time it is embarrassed in establishing rules and regulations which would compel all the companies to be more liberal and progressive than the city itself is.

5. I have left till the last the most intricate and difficult of all the problems of regulation which the department has undertaken. I refer to the fixing of rates. Every rate problem, even under the simplest conditions found in common experience, is complex and difficult. But many special complexities and difficulties are encountered in the case of the private water companies in New York City. I cannot hope within the scope of this paper to do more than give a bare outline of these difficulties and of the ways in which the department is trying to meet them. Our work is still incomplete, and the degree of success attained still somewhat uncertain.

(*a*) *Basis of Valuation.* Difficulty has been experienced in securing the accurate records of cost in relation to some of the companies that would have enabled the department to use the actual-cost method as the basic factor in its valuations. Some of the companies have thrown their books open to examination by the department's accountant, while others have refused to permit such an examination and have supplied the department with only a limited amount of information as to their cost records. Under these conditions it seemed necessary to use the reproduction-cost method as the basic factor, but this method, always considerably theoretical and unreal, has been, in the case of the private water companies of New York City, subject to certain special limitations peculiar to the time and place.

The element of *land*, which in the case of the largest of the companies is an exceedingly important factor, was affected by the fact that the lands in use for water supply, lying for the most part within the limits of the Greater City, were inevitably decreasing in value as sources of water supply, while, at the same time, they were increasing in value for other purposes. In some cases the application of the reproduction-cost theory to land would have

led to a most fantastic result, since the value that would have been attached to the land for general real estate purposes would have been out of all proportion to its possible value as a source of water supply; although a value could be assigned to it for water purposes representing many times its original cost to the company.

With relation to the value of *wells, buildings,* and *pumping equipment,* it was found that the reproduction-cost method could not be used except with a liberal allowance for obsolescence and inadequacy, arising out of the fact that either the location of the wells and the pumping stations, or their use in connection with the water supply of the district served, had become or was about to become obsolete. In some cases, an estimate of value of all the separate items found in the inventory, on the theory that they were all live, "going" property, would have brought a total result out of all proportion to the actual value of the property as a whole under the conditions under which it was being operated or was likely to be operated in future.

The reproduction-cost method, if applied strictly on the basis of unit prices prevailing at the present time, would have brought fantastic results because of the abnormal price conditions which apply to both labor and materials. Yet nothing is more certain than that a water plant reproduced new at the present time would have to be constructed at a cost measured by most extraordinary prices. But the tempest that is sweeping across the face of the world leaves us all in doubt as to how long abnormal prices will continue, and as to whether or not they will ever get back to the old levels. So far as my experience goes, most engineers expect the continuance of the present high prices for a time at least long enough to swallow up the three- or five-year period often used as a basis in fixing unit prices.

In meeting these several difficulties, we made use of the reproduction-cost method, but applied it with certain qualifications. For example, we assumed that the physical conditions on the basis of which the estimate was made were the *original conditions,* and not those now existing. In particular, the item of *pavements,* in so far as they represented construction installed after the installation of the mains, was disregarded. With reference to *land* we excluded as obsolete those lands which had become too valu-

able to be continued as sources of water supply when the amount of water that could be taken out of them was considered. We also excluded lands which were unnecessary for water purposes, but which had been acquired, perhaps wisely from the financial point of view, at the same time when the water-bearing lands joined with them had been acquired. We also excluded lands acquired for water-supply purposes which had never been put to use, and which, under the circumstances surrounding the operations of the company, in all probability never would be put to use as water lands. In fixing the value of lands for water-supply purposes, we took into consideration the fact that so far as they are necessary from the point of view of the private company's continued operation they are held subject to the burden of public service which prevents the owners from releasing them for other uses without public consent. Our valuations were commenced during a period of normal prices, and were based upon average prices during the period of from three to five years immediately preceding the European War. Even now, in applying our valuations, we would make use of the old prices. Of course, a company which is compelled to make additional investments at the present time ought to receive consideration on account of the extraordinary cost of the portions of its construction undertaken during this abnormal period. Such consideration should be given, however, not in the form of increased unit prices, but in the form of extras applying to the work actually done during the period, just as extra allowances are made for other peculiar conditions, such as the presence of rock, the installation of pipe lines below the water level, etc.

(*b*) *Method of Applying Depreciation.* Water-works systems are usually regarded as long-lived properties, but the conditions affecting the private water companies on Long Island are somewhat peculiar in this respect. In the first place, as their supplies are local and as no large storage capacity has been or can be provided, the element of masonry construction in the form of reservoirs and aqueducts is almost entirely absent. Then again, the wells, buildings, and pumping stations, which in any case are not very long-lived, are, under the circumstances that prevail with these companies, subject to rapid depreciation on account of ob-

solescence and inadequacy. Part of this depreciation is what might be called artificial because of the potential competition of the city plant and the big fact staring the companies in the face that when the city takes over their service or extends its own service into their territories, these portions of their property will no longer be of any particular value for water purposes, as the city now has an entirely different source of water supply and a different method of operation. Even the distribution systems, which, under ordinary circumstances, are properly regarded as long-lived property, are, in the case of these companies, subject to comparatively rapid depreciation because of inadequacy. The small mains which have been deemed sufficient in the outlying sections of the city will have to be replaced sooner or later as these sections are built up more closely and as they develop a demand for water supply and fire protection commensurate with city standards. It has been necessary for us, giving consideration to all these elements, to regard the companies' plants as a whole as short-lived properties. We applied the straight-line method of depreciation because it is more appropriate under these circumstances, and also because it is simpler than the sinking-fund and equal-annual-payment methods.

(c) *Effect of Actual or Potential Competition upon the Rate of Return.* One of the companies is protected from immediate competition by the city by a legislative act. This, however, is subject to repeal at any time. All the other companies operate subject to the danger of municipal competition. Indeed, in some cases, the city already has its trunk mains through their territories distributing water to districts on both sides of them. In one ward of the borough of Queens, having a population of about 150 000, the company that is supplying the general service was subjected, a few years ago, to the competition of a rival which had picked up and revived an old franchise long fallen into disuse. This rival established a pumping station, and went into business with the avowed purpose of supplying the large consumers in the manufacturing district in one corner of the ward; and, without making any effort to secure domestic consumers, it proceeded to put into effect a competitive rate for industrial plants even lower than the city's rate and certainly lower than any rate

that would yield a fair return if applied uniformly to all the consumers who are being served by the older company. As a result, the new company, although now having only one large consumer and eight small ones, is now taking away from the company rendering general service net revenues representing nearly two per cent. upon the latter's necessary investment. The older company could get a seven per cent. return on its investment, if it had even the one large consumer in addition to its own, at rates that would yield only about five per cent. with the consumers which it now has. Ordinarily, in the process of regulation of public utilities, the presence of actual competition or the danger of potential competition would lead the regulating authority to allow the company whose rates are being fixed a higher rate of return upon its investment than would otherwise be necessary, this higher rate being based upon the increased risk to both investment and revenues caused by competition. But in the case of the private water companies in New York City it is clear that a higher rate of return upon the investment, reflected in higher water rates or poorer service than would otherwise be necessary, would have the direct effect of stimulating competition and thereby increasing the risk on account of which the higher rate of return was claimed. Ever-increasing danger to the investment would be the result, which logically would require further increases in the rate of return allowed. In other words, the application of the usual rule in relation to the rate of return upon the investment would render regulation absolutely nugatory. We took the position, therefore, that the danger of competition should have, if anything, the opposite effect upon the rate of return to be allowed, since the first duty of the regulating authority, from the point of view of the interest of the corporation whose rates are being fixed, is to protect the investment. We believe that the best way to protect the investment, under the circumstances prevailing in these cases, is to keep the rate of return down close to the minimum that will cover the cost of securing money; for in this way charges can be reduced or service improved and the dangers of competition minimized, with a resultant increase in the safety of the investment and the dependability of the revenues from operation.

(*d*) *Effect of the Established City Rates.* As the city of New

York has invested enormous sums of money to develop an ample municipal water supply, and already serves directly more than 90 per cent. of its citizens, it is natural that the rest of them who, though taxpayers of the city, are still dependent upon private companies for water supply, should demand at least uniformity of rates and equality of service as the price of their acquiescence in the continuance of the private water companies in business. It is often supposed that a city by developing an immense water supply and doing business with a great many consumers can reduce the cost of water service per capita below what it would be if continued on a smaller scale. This is undoubtedly true under certain conditions, but it is no longer true in the city of New York when comparison is made between a city of more than 5 000 000 people, bringing its water supply from far-distant watersheds, and a restricted portion of the same city served by a private water company from local sources. Undoubtedly if the municipal water works of the city of New York were owned and operated by a private corporation, the revenues derived from the rates would have to be more than twice as great as they now are, to provide the company with a fair return upon its necessary investment. It does not follow, however, that a private company serving one of the wards of the borough of Queens, and deriving its supply from wells located within the area of service, cannot operate at a profit while charging the same rates which the city now charges. Indeed, it is conceivable that the city rates might, under such circumstances, be too high. The points I am trying to make are, first, that the city rates, as such, are no indication of what the rates would have to be if the municipal plant were operated by a private company; and, second, that the rates charged for the general city service either by a municipal plant or by a private plant serving the entire city have no logical relation to the rates necessary to maintain a local investment in the service of a restricted district depending upon a local supply. Nevertheless, the fact remains that in establishing rates for the private water company territories, the commissioner has to keep in mind the public demand for uniform rates to all citizens of the Greater City wherever they may reside.

Another peculiarity of our situation is that the city on its own

service charges a uniform rate per unit for all water consumed if metered, whether the amount be large or small. This uniform-rate policy differs from the policy usually adopted by private water companies, and, for that matter, by public-service commissions in fixing water rates. But for reasons which the city considers satisfactory this theory of rate-making has become well established in New York, and it has become a matter of considerable importance that the rates of the private companies should be made to conform as nearly as practicable to the principles which govern the city rates. It is particularly important to the city that the companies should not be permitted to adopt a rate schedule favoring large consumers and giving them a lower rate than the uniform rate on the city service, for this would put a premium upon the activities of companies whose purpose would not be to render general service, but rather to take the cream of the business, leaving to the city that which is most expensive and least remunerative. We have, therefore, as our objective, so far as metered water is concerned, the establishment of rates that shall not be lower than the uniform city rate, but that shall approximate this rate as closely as the circumstances of the individual company warrants.

(*e*) *Distribution of Cost between Domestic Service and Public Fire Protection.* The water department does not have to pay taxes on its property within the city limits. On the other hand, it receives no compensation from the taxpayers for the water furnished for fire protection and other public uses. Indeed, heretofore, no attempt has been made even to estimate and record as a matter of bookkeeping the value of the free service rendered by the department or of the free service received by it. Obviously, however, this rule could not be applied by a rate-fixing body to a private water company, and thus it became necessary for the commissioner, in establishing the basis upon which the water companies' rates should be fixed, to determine the proportion of the companies' revenues which ought to be derived from the two services, respectively. After careful consideration of the several theoretical bases for this distribution which have been put forward by different authorities, the department decided that under New York City conditions it is proper to assume that the private

water companies went into business primarily for the purpose of selling water for profit to domestic and business consumers, and that the service which they are under obligation to render to the public is an incidental or supplementary one imposed upon them as a condition of the special privileges they enjoy for the occupation of the public streets with their pipes. This does not mean that this service must be rendered free, but merely that it should be charged for at cost as a supplementary public service. We attribute to public fire protection that portion of the investment which represents an increase over the investment that would have been required for a plant entirely adequate if required to furnish domestic and business service only. We also attribute to fire protection so much of the operating expenses as represents a similar increase over and above what the operation of a plant for domestic and business service only would cost. We do not maintain that this method is necessarily applicable under all conditions, and, possibly, in small towns or in suburban communities receiving their supply from larger municipalities, the Wisconsin method of treating fire service and domestic and business service as coördinate may be more appropriate to bring about a just and politic result. But, so far as the private water companies in New York are concerned, under the peculiar conditions there existing, we believe that the method being pursued is the right one.

After determining the portion of the revenues to be derived from public fire protection, which is usually paid for in the form of hydrant rentals, we concluded that it would be better to divide this contribution into two parts: one, a lump sum to be paid by the city on account of the general investment attributable to fire protection, and the other, a sum made up of hydrant rentals, these rentals to be fixed at a figure that will just cover the actual and necessary cost of the specialized investment in the hydrants and of their maintenance. This plan takes care of the general investment existing at the time when the rates are fixed, and also provides a reasonable basis for the extension of hydrant service in connection with the existing mains. We realize, however, that it needs to be supplemented by some method that will measure the proportionate cost of additional investment in distributing mains and other facilities installed from time to time. We have not

adopted the plan of charging to fire protection a fixed sum per mile of mains in service, nor a graduated scale by which different amounts would be charged for mains of different sizes. We recognize that either of these plans is a simple one, and that it may for practical purposes under certain conditions work out a reasonably just result. We think, however, that a still better plan, where proper administrative conditions exist, is to have the chief engineer of the water department certify the proportion of the cost of every additional main as it is laid that is properly attributable to and necessary for public fire protection, and to add to the company's investment for fire protection purposes the portion so certified, and upon this additional amount to pay the company a fair rate of return, say 10 per cent. per annum, to cover interest, depreciation, taxes, etc.

(*f*) *Going Value.* The United States Supreme Court has held in many cases that accrued depreciation should be deducted from the reproduction cost of a public utility's property. Some of the leading state commissions and courts have, on the other hand, held that "going value," so called, is an element to be taken into consideration in determining the amount of the investment upon which the rates should yield a fair return. This going value is not the same as the going value defined by Justice Brewer in the Kansas City water-works case, as the additional element of value attaching to a water plant with its connections established and earning a revenue as compared with a water plant constructed and ready to operate but without any connections or business. The going value recognized for rate purposes might better be termed "going cost," or the cost of developing the business, and the highest court in the state of New York has held that this value represents the accumulated deficiencies below a fair return upon the investment which have not been later made up to the company by profits in excess of a fair return. In the case of a company that has been prosperous, the going value for rate purposes would not exist, while in the case of a company that has had a long series of lean years and has only now begun to earn a fair return upon its investment, the element of going value might be a considerable one. This, of course, is exactly the reverse of the theory of going value, or good-will, in a purchase case where

the price is fixed by voluntary negotiations. For purchase purposes the property is made more valuable by profits, while for rate purposes it is made more valuable by losses! Apparently, the mandate of the United States Supreme Court requiring that depreciation be deducted in a rate case may be entirely circumvented by the application of the theory of going value, which may make up in the form of intangibles all or more than has been deducted on account of depreciation. We found in the case of one private water company that it had never had any prolonged period of leanness. On the contrary, through its hydrant rental and water purchase contracts it had received a very large proportion of its total revenues from the city, with the result that it was able to pay fat dividends almost from the commencement of operation. But owing to the profit derived by the company from the water contracts, and the prospect that the city might take still more water, the company was tempted to extend its plant and acquire new sources of supply far beyond the immediate requirements of the territory occupied by its private consumers. The result was that after a while, when the city no longer needed to purchase water from the company, the latter was left with an over-developed plant upon its hands and an inflated capitalization based upon the rich profits of its earlier years and the assumed appreciation in the value of its land for water purposes. Under these circumstances, it was not altogether unnatural that the over-developed plant should fall into a degree of disrepair and that the habit of paying a fixed dividend upon inflated capital should prove stronger than the desire to maintain the property in the highest practicable state of efficiency. At any rate, it appeared that the company had withdrawn, in the form of high dividends, profits well in excess of what is now regarded as a fair return upon such an investment, while at the same time it had neglected to make adequate provision for depreciation.

As the result of careful consideration of this case, we determined that where a company has made the payment of dividends its first aim and has been niggardly in its provision for the maintenance of its property and its service, it is not the function of the regulating authority to delve deep into the dust of the past and reconstitute the company's accounts by setting up an allowance

for depreciation, and thereby, perhaps, establish a "going value" for rate purposes even though the dividends withdrawn from the property have been high from the beginning. On the other hand, if a company, having the same investment and the same earnings, has, in a spirit of conservatism, properly kept up its plant and provided for depreciation, and as a result of this policy has been unable to pay to its stockholders dividends up to a fair return upon their investment, then the rate-fixing authority may properly take this into consideration and make an allowance for going value based upon such accumulated deficiency. It is in this way that a company's attitude towards the public service can properly be penalized or rewarded in connection with the fixing of rates, and it is in this way that the doctrine of the United States Supreme Court, requiring the deduction of accrued depreciation, can be reconciled with the doctrine of the New York Court of Appeals that going value shall be allowed in rate cases where there has been a deficiency in the amount of profits received from the business.

Discussion.

Mr. H. F. Dunham. I should like to inquire what special features tend to make the life of these water companies so short.

Mr. Wilcox. There are no reservoirs or large conduits which constitute so large a portion of the property in some water plants and which are very long-lived. The mains tend to be smaller than the requirements of the city's future demand; therefore there is a more rapid depreciation on account of obsolescence in the distribution system than would otherwise be the case. The pumping plant and the wells are short-lived properties anyway, and they are also subject to depreciation by obsolescence because of this great change that is coming over the water-supply situation in New York through the development by the city of the large additional supplies which will inevitably, sooner or later, make these portions of the private companies' plants obsolete, whether or not they are purchased.

HARTFORD WATER WORKS, PAST AND PRESENT.

BY W. E. JOHNSON, DIVISION ENGINEER, RESERVOIR DIVISION.

[*Read September 13, 1917.*]

The following paper has for its object a brief sketch of the growth and development of the Hartford Water Works from its incorporation to the present time, covering a period of more than half a century.

During the early part of this period the supply was taken by pumps from the Connecticut River, and later by gravity from a drainage area on the eastern slope of Talcott Mountain in the towns of West Hartford, Farmington, and Bloomfield.

Previous to the adoption of the plan for a water supply from the Connecticut River with pumps operated by steam power and located to the north of the city, various projects were considered. One of these, which attracted considerable attention and was favored by many, was to construct a canal from Hartford to Windsor Locks, located about twelve miles up the Connecticut River, and utilize a portion of the water thus obtained in developing power to be used in pumping water to an elevated reservoir from which the city would take its supply.

The Hartford Water Works was incorporated in 1853. In that year surveys, plans, and estimates were made and contracts let with the approval of the Common Council. The following year construction began.

The first annual report of the Board of Water Commissioners is dated April 23, 1855. This report is principally devoted to a statement of the situation and condition of the works when they accepted office, disclaiming credit for the work, as undertaken, and giving to their predecessors all the merits or demerits of the plan. The report consists of ten printed pages, and considerable space is given to criticizing the action of the previous board, pointing out mistakes and lack of judgment of the Common Council, engineer, and prominent citizens.

The plant as built consisted of a pumping station on the Connecticut River at the foot of Pleasant Street, a sixteen-inch force main one and one-fourth miles long, and a distributing reservoir at an elevated position in the western part of the city now known as the Garden Street Reservoir.

The pump was comprised of four cylinders set vertically, in which operated two lifting pistons containing the valves, the upper piston being operated by a hollow piston rod through which the rod of the lower set of valves worked. The cylinders had an internal diameter of 19 in. and a 16-in. stroke. The pumps were driven by gears having hard-wood teeth working from pinions on the main engine shaft. The bottom of the cylinders was located about 10 ft. above mean low water in the river, and they received the water through a 24-in. conduit extending from the pump well to an intake in the channel of the river, a distance of 140 ft.

The engine was of the condensing beam type, with cylinder 32 in. in diameter and 60-in. stroke. The engine and pump were built and installed by the Woodruff and Beach Iron Works, of Hartford, Conn.

The Garden Street Reservoir has a flow line elevation of 125 ft. above mean low water in the river, and was originally considered to be of sufficient elevation and capacity for a long period of time. The maximum depth was 30 ft. and the capacity 8 000 000 gal. It was soon apparent that the capacity of the reservoir was insufficient and the elevation such that the reservoir had to be kept practically full to give the required pressure, thereby necessitating the operating of the pumps longer and at more frequent intervals.

The pumps were first put in operation October 20, 1855, and continued to supply the city until the gravity supply was put in operation in 1867.

As early as 1857 the board found that there was a much higher consumption of water than the conditions warranted, attributed to waste from defective and improper plumbing and because during the cold season the water was left running to prevent freezing. They advised a general use of stop and waste valves on the services, and the appointment of an inspector whose duties would be to superintend the placing of new house connections and the

inspection of house plumbing and fixtures. They stated emphatically that, with the present capacity of the works, the necessity of checking the waste was of vital importance.

During the early period of the water supply, there seems to have been but little reliable data as to the approximate number of persons supplied with water, the water rates being based on the number of outlets and fixtures in the houses. The annual report of March 1, 1863, gives an estimate that the population supplied about 26 000, making a per capita consumption of over 51 gal. In the following table is given the average daily consumption by years from 1857 to 1866 inclusive, which were compiled from the pump duties.

TABLE OF CONSUMPTIONS.

Year ending March 1.	Average Daily Consumption. Mil. Gals.
1857 (10 months)	.34
1858	.51
1859	.66
1860	.78
1861	.90
1862	1.10
1863	1.35
1864	1.54
1865	1.84
1866	2.15

In 1858 the board began investigations relative to an increased supply of water. Their report on the subject was submitted to the Common Council in April, 1860. This report recommended a supply of water by gravity from the hills to the west of the city, and urged the Common Council to take immediate action on the matter of an additional water supply. In succeeding years the board continued its investigation and called attention to the vital question of an additional supply.

There seems to have been, at an early date, a diversity of opinion and much discussion in the city whether new pumps with a reservoir at a more elevated position or a gravity supply from

Talcott Mountain should be adopted. The following paragraph, taken from the report of 1864, indicated the interest aroused in the public concerning the additional water supply.

"It is much to be regretted that, in so vitally important a matter as an additional supply of pure and wholesome water for the daily use of our growing city, attempts should be made to bias the public judgment in favor of, or against, this or that project, by anonymous and irresponsible writers who have neither investigated nor have means of investigating a subject of this character; and unless the voting class will have the wisdom to discard, utterly, all representations made upon this subject by anonymous and ignorant or interested parties, and base their action upon the authenticated results of careful investigations, made by experienced, skillful, and responsible engineers of known integrity and ability, we shall be very liable to fall into a very grave mistake in the matter and discover our error when it is too late to correct it."

It was during this period that all possible means for utilizing the total capacity of the pump and conserving the supply was made. The size of the air chambers on the pump was increased, the speed of the pump accelerated about twenty-five per cent., a thorough investigation relating to leakage from the force main and distribution was made, and later the supply was pumped directly into the distribution. The result of the last mentioned was to furnish unsatisfactory and turbid water, which probably had the effect of hastening the action tending toward a new and additional supply.

In May, 1861, the Common Council authorized the board to employ such assistants as needed to re-examine and report anew on the various projects for a water supply for the city. In consequence of which, the board employed competent engineers and chemists to advise with them, and, although extensive investigations and reports were made and submitted to the council, no definite results were obtained.

The question was finally brought to a definite conclusion in the fall of 1864, when it was referred by the court of Common Council to a city vote, and was decided in favor of a supply by gravity from Trout Brook by a vote of 1 510 for and 508 against the project.

The plan for an additional supply submitted by the Board was approved by the court October 11, 1865, and contemplated impounding and taking water from Trout Brook in the town of West Hartford, and immediate steps were taken to carry out the plan.

At the very beginning of the gravity project the board was confronted with many obstacles in form of injunctions, lack of uniform action in the two branches of the Common Council, and want of adequate legislative rights.

In March, 1865, the board petitioned the General Assembly for an amendment to the city charter which would enable them to take water from Trout Brook in the town of West Hartford, which was finally granted.

The new supply by gravity was obtained by storing water from Trout Brook drainage area on Talcott Mountain. A dam was constructed a short distance below the junction of three branches of the stream, having a flow line elevation of 260.0 ft. above mean low water in the Connecticut River at Hartford.

Water was first introduced in the city from this source in January, 1867.

The following year Reservoir No. 2, located on the upper portion of the drainage area, was built, and an additional watershed of .8 square miles was added by means of a canal connecting Mountain Stream with Trout Brook. In 1870, the dam of this reservoir was raised five feet, increasing the capacity to 284 million gallons. Reservoir No. 3 joins Reservoir No. 2 on the south, with a water line at a slightly higher elevation, and was constructed in 1875, having a capacity of 146 million gallons. In 1880, Reservoir No. 4 was added to the system. This reservoir has a capacity of over 600 million gallons, and is located on a new drainage area, southwest of the original watershed. The water in this reservoir is conveyed to Reservoir No. 1 by a 24-in. cast-iron pipe. The yield of this reservoir was increased by the addition of Dead Swamp Canal two years later; this canal was not extended to its ultimate length until 1905, and now drains a watershed of 2.08 square miles. Reservoir No. 5, located between Reservoirs No. 1 and No. 2, was constructed in 1884. The last reservoir of the present system, known as the "Tumble-Down Brook Reservoir," or Reservoir No. 6, was built on a watershed joining Trout Brook

drainage area on the north. This reservoir added 765 million gallons to the storage, and is connected with Reservoir No. 5 by a 24-in. vitrified pipe line, and was completed in 1896.

The aggregate storage of the six reservoirs is 2 036 million gallons, and takes the water from a drainage area of 11.92 square miles, of which .68 square miles is water surface.

The safe yield of the present works has been estimated at 7.5 million gallons per day. In 1916 the average daily consumption was more than 10.5 million gallons. These figures indicate the importance of the new works now about brought to completion for the city of Hartford.

HARTFORD'S DISTRIBUTION SYSTEM.

BY FRANK BRAINARD, ASSISTANT ENGINEER.

[*Read September 13, 1917.*]

Previous to 1854, there was a small water-works system in this city owned by private parties. A small reservoir was located near what is now Park and Putnam streets. It received most of its water from springs, and the main pipes used to conduct it were principally wooden. These were evidently made by simply boring a hole lengthwise through a piece of wood about six feet long, then tapering one end and making a deep socket in the other, similar to the bell-and-spigot style in present use, while the outside received no other treatment than the removal of the bark. A length of this pipe was taken out of Kinsley Street in 1911, when we were laying a new main, and may now be found at the house of the Veteran Firemen's Association, where it is kept with other curiosities. It was originally about 6 ft. long and 8 in. in diameter, with a 2-in. hole or waterway. About two feet of this pipe was badly decayed and has since been cut off; the remainder, however, is in a good state of preservation.

In 1854 the present distribution system was started, and the Garden Street Reservoir built for distributing water pumped to it from the Connecticut River through 6 879 ft. of 16-in. cast-iron pipe, which is still in service. The engine and pump are also in a semi-serviceable condition, having been overhauled this spring, and run for a few hours, and are now in as good condition for use as possible in case of emergency.

Ten years after the system was started, — that is, in 1864, — there were 2 434 service pipes and approximately 32 miles of main pipe, which was of cast iron, with the exception of about 4 000 ft., the latter being cement with a sheet-iron lining.

But the new system had not been in use long before it became apparent that the Garden Street Reservoir was not large enough for the needs of the city, it having a capacity of only a little over

8½ million gallons. So, in 1866, the present reservoir system was commenced, and a 20-in. supply main was laid from Reservoir No. 1 into the city, where it was connected with the system already in use. Most of this new main was cement, lined with sheet iron, but in ten years' time a part of it was replaced with cast-iron pipe, owing to the number of leaks which developed, especially at the joints.

Between the years of 1864 and 1872, a large amount of this cement-lined pipe was laid, ranging from six to twenty inches in diameter, the last being laid in 1883. The greatest amount in service at any one time was about 18¼ miles. Because of the numerous leaks developing from time to time, it was decided in 1885 to replace all of this pipe with cast iron, so that at the present time the only cement-lined pipe still in service is about 700 ft. on Sumner Street, and this is to be renewed in the near future.

Because of the increased demand for water, two additional supply mains, a 20-in. and a 30-in., were laid in 1874 and 1896 respectively, and by 1895 the sixth reservoir had been built, their total capacity being 2 billion 100 million gallons. But, for all this rapid addition of reservoirs and supply mains, the city was constantly in danger of having to resort to the Connecticut River during every dry season, because of the great waste of water by consumers. To overcome this difficulty, it was decided in 1899 to meter all water except that used for fire purposes. Previous to this time, meters had been installed only in hotels, livery stables, and some manufacturing plants, the first ones being installed in 1877.

In 1901, with nearly 30 per cent. of the services metered, the average daily consumption was about 7 million gallons, or 84.6 gal. per capita, while in 1906, with 98 per cent. of the services metered, the average daily consumption was only 6.09 million gallons, or nearly a million gallons less. It was not until 1909, or eight years later, that the seven million mark was again reached, at which time the per capita consumption was 71.6 gallons, or 13 gal. per capita less than in 1901. It has not been necessary to resort to any other supply since the general installation of meters, but we have been very close to it, and without question would have been obliged to do so if it had not been for the meters.

As it was suspected that some of the factory fire-services were leaking underground, and that the privileges for the use of same were being abused, in 1907 twelve detector meters were installed on as many fire services. By the installation of these meters, it was estimated that 19 million gallons of water were saved, and that the revenue was increased about $330 the following year.

In 1907 we awoke to the fact that our system was in constant danger of pollution from the fire pumps located in several factories. These factory fire-systems are operated at a pressure much greater than that of the city, and the only protection in use at that time was a single check valve. If this should fail, the fire pump would discharge directly into our system. As most of these pumps receive their supply from the Park River, which is highly polluted, it was decided in 1907 that all these connections must be equipped with double check valve systems, fourteen of which are now in service.

These double check valve systems consist of two check valves so connected and fitted up that each one may be tested separately for leaks under any pressure we may see fit to use. There is also an automatic electric alarm system connected with them, that rings a bell in the office of the factory in case one of them is leaking when the pumps are in operation. These check valves were installed under our direction by the factory owners, who bear all cost of inspection and repairs. A monthly inspection is given them by men from the water department, and they are taken apart and cleaned once a year.

For some years previous to 1908 it was known that the small mains in the center of the city could not furnish adequate protection in case of a large fire. It was therefore proposed to lay a 24-in. main, or belt line, around the Conflagration Area, as defined by the New England Insurance Exchange in 1906. The inside of this area was to be gridironed with mains ranging in size from 8-in. to 16-in. This work has now been completed, so that it is possible to concentrate about ten thousand gallons of water per minute on any block in this area.

On Prospect Avenue, south of Albany Avenue, there is a sudden rise of ground known as Prospect Hill. This is one of the highest points in the city, and during periods of maximum draft

the water does not reach the top of the hill. In order to furnish fire protection to this section, check valves have been installed in the main pipe each side of the hill between two hydrant connections which are about 25 ft. apart. In case of fire, water is pumped by fire engines from the hydrants connected below the check valves into the hydrants connected above, and is thus forced up the hill through the main pipe, where it is made use of by hydrant streams.

With the introduction of the electric railway cars came the danger of electrolysis to our underground system. The greatest damage from this source occurred between the years of 1907 and 1912, at which time the railroad had twelve steel rails that were laid underground from the State Street car barn, through Grove and Commerce streets, to their power station, for a negative return system. These rails were not insulated, and as the water pipes were highly positive to the rails, the electric action was very great. It was necessary in 1909 to replace eight service pipes in the vicinity of Grove Street, which were leaking badly, due to this action. One of these pipes had been in service only three years, although their average age was ten years.

In 1909 the trolley company installed several wooden insulating joints in our mains near this danger section, in an attempt to break up the flow of electric current on our mains toward their power station. While these were partially successful, in that they stopped the flow on our mains at that point, they did not, however, help the situation to any great extent, as the current passed these joints by means of other underground structures, and returned to our pipes again, after passing. These joints consisted essentially of an ordinary pipe joint, with the lead space filled with wooden wedges, and a wooden ring slipped inside of the bell end of pipe, to keep the spigot end from "bottoming." A double joint of this kind was used for greater security, being made up in as small a length as convenient.

Five years ago the rails were removed and overhead wires substituted for their negative return system, since which time the conditions have been much improved, and to-day we have very little damage from this source.

Owing to the need of additional space in which to store pipe

and special castings, a tract of land situated at the corner of New Park Avenue and Flatbush Avenue, containing about six acres, was purchased in 1909. This storage yard is adjacent to the main line tracks of the New York, New Haven & Hartford Railroad. A spur track has been run into it from the railroad, and a trolley system constructed for the handling of pipes delivered there. All pipe and special castings for the use of this department are now received at this place, which we call the New Park Avenue Yard.

The meter department is located at the old storage yard on Union Street. All meters are tested here before being installed; they must register not less than 98 per cent. and not more than 100 per cent. of the water passing through them on a full flow, and the smaller sizes must register on a $\frac{1}{32}$-in. stream. It is planned to remove all meters at least once in three years, for cleaning and testing. The machine, carpenter, and blacksmith shops are also located at this yard, as well as the garage for the auto trucks and the barn for the horses used by this department.

On March 1 of this year there were in service 199.41 miles of main pipe, ranging in size from $1\frac{1}{2}$ in. to 30 in., with about three miles less than 4 in. in diameter. All mains 4 in. or over in size were cast iron with the exception of 700 ft. of 6-in. cement-lined pipe, and all less than 4 in. in diameter were galvanized wrought iron; there were 4 042 stop gates, 15 404 service pipes, and 15 077 meters. The service pipes were principally galvanized wrought iron, although there were some brass, lead-lined, and cement-lined pipes in use. The average life of a service pipe is about twenty-five years.

The estimated population supplied during the past year was 163 000, with an average daily consumption of 10.6 million gallons and a per capita consumption of 65 gal.

The pressure ranges from 10 to 100 lb. during periods of minimum draft, but is about 20 lb. lower during periods of maximum draft. This variation will be overcome, however, when the 42-in. supply main now under construction is completed.

DISCUSSION.

MR. MCFARLAND. I am interested in your statement that over 90 per cent. of your service is metered, which is a large percentage. Have you a meter of water which is pumped or delivered at your station, so as to determine what percentage of the water is accounted for through meters?

MR. BRAINARD. The water is all delivered by gravity; there is no pumping station. There is a master meter located at the reservoir, which meters all the water which comes into the city.

MR. MCFARLAND. What percentage of that water is lost? How much is the loss between the meters?

MR. BRAINARD. There is about 85 per cent. of that which is accounted for on the small meters; about 15 per cent. is not accounted for.

MR. MCFARLAND. You stated your service pipes were wrought iron. Do you mean wrought iron or steel?

MR. BRAINARD. Galvanized wrought iron.

MR. MCFARLAND. You don't use the steel pipe at all?

MR. BRAINARD. No, sir.

MR. L. M. HASTINGS. I was interested in what Mr. Brainard said about the electrolysis and the loss and injury to pipes from that cause. Now, we have suffered from that cause very greatly. The services that we put in will sometimes not last more than a year, and then be entirely corroded in that time. The Boston Elevated Company has taken some steps to regulate it, but there has been nothing that has been very effective. Now, as I understand it, you said there was an overhead return wire laid from your danger district back to the power station. Can you explain that a little more fully, so that we can see what that return feed is, and how it is arranged to reduce the leakage?

PRESIDENT SAVILLE. On that matter of electrolysis, I should like to say that we have had very little trouble. Previous to about five or six years ago, that matter was handled by some electrical engineers that were employed spasmodically by the board. Within the last four years we have been handling that through another assistant than Mr. Brainard, and I will ask Mr. Garratt if he will kindly reply to that question which has just been asked, — about the back flow.

MR. GARRATT. The railroad return feeders consist of twenty-one 1 000 000 circular mill cables, which connect with the rails and take the current back from six different points. These points are located within a half mile north and south of the center of the city and between the railroad and the river. Since they have installed those return feeders it has changed the danger area, the positive area in the city, from the southern end of the city to points near those bond connections.

MR. HASTINGS. What do you say as to the danger from electrolytic action?

MR. GARRATT. The danger has been reduced in area. It has changed the locations, and whether we are going later to have bad conditions in those areas, we don't know.

MR. H. F. DUNHAM. Have you made investigations to know how much you are carrying on your pipe lines?

MR. GARRATT. Yes, we have current load stations where we take measurements each year. The current has been materially reduced by the installation of this new return feeder system of the railway.

MR. DUNHAM. Is there any difference between summer and winter?

MR. GARRATT. I have not looked into that. We have taken observations in winter as well as in summer.

PRESIDENT SAVILLE. I will say, regarding the double check valve system Mr. Brainard spoke of, that within a year the board — recognizing the rather ridiculous and illogical condition which arises from a city which is about to spend hundreds of thousands of dollars to safeguard its water supply and filter it and see that there is no pollution in any way whatsoever — has passed a vote prohibiting the extension of the double check valve system, so that there shall be no more physical connection with polluted sources even if it is governed by a so-called safeguard.

ENGINEERING ON THE ADDITIONAL WATER SUPPLY FOR THE CITY OF HARTFORD.

BY H. W. HORNE, DIVISION ENGINEER.

[*Read September 13, 1917.*]

The Board of Water Commissioners of the city of Hartford have just finished an impounding reservoir of 9½ billion gallons capacity for an additional supply to its present system. This reservoir, known as the Nepaug Reservoir, is located in the towns of Canton, New Hartford, and Burlington, and is about fourteen miles west of Hartford, the nearest railroad station being Collinsville. The reservoir was formed by building two dams and a dike: one dam, a concrete masonry structure, on the Nepaug River, which flows into the Farmington River 1¼ miles above Collinsville; the other dam, an earth structure with a concrete core wall carried to ledge rock, on the Phelps Brook, which flows into the Farmington River 1¼ miles below Collinsville, and the dike, built of earth with a concrete core wall, at a low divide at the northeast end of the reservoir. The water from these streams is backed up over a broad flat divide between them, where the water will be 27 ft. deep with the reservoir full. The watershed supplying the reservoir covers 32 square miles in area.

Besides building the Nepaug Reservoir from which the city of Hartford will get its water supply, it was necessary to build a compensating reservoir of 3 billion gallons capacity, to store water to compensate the mill owners who would be deprived of the flow of the Nepaug River and of the Phelps Brook. This reservoir, known as the East Branch Reservoir, is located in the towns of New Hartford and Barkhamsted on the east branch of the Farmington River, about one mile east of the village of New Hartford. The dam on this river, an earth structure with a concrete core wall, carried to ledge rock, is under construction at the present time.

The engineering work which was necessary for the building of

the Nepaug and East Branch reservoirs may be divided into two groups, — preparatory engineering and constructive engineering. Under preparatory engineering is classed triangulation, bench leveling, property surveys, topographical surveys, including detailed topography at the dam sites, and all work necessary for the preparation of the contract plans. Under constructive engineering is classed all lines and grades given for construction work and all measurements taken for estimates for payments to the contractors.

In any engineering project of the magnitude of this work, the surveys must be accurately tied together, and for this purpose a triangulation system was first established in each reservoir basin, suitable stations selected, and a base line measured. At the Nepaug basin there were nine stations, and at the East Branch basin ten stations. The angles at each station were read twelve times. The reservoirs are about four miles apart, and although entirely separate projects, it was thought best to tie the two triangulation systems together and connect them with the West Hartford reservoirs. For this work two United States Geological Survey triangulation stations were selected: one, "Talcott," on Talcott Mountain in Avon, about eight miles east of the Nepaug Reservoir, and the other, "Johnny Cake," on Johnny Cake Hill, in Burlington, about five miles southwest of the Nepaug Reservoir. These stations are 57 361.8 ft. apart, and, with this distance as a base line, a system of stations was established and connected with the two local systems at each reservoir. There were fourteen stations in the large system, and the angles were read sixteen times at each station.

Bench levels were run from No. 1 reservoir at West Hartford to each reservoir location, and numerous bench marks established for use in topographical surveys and for construction work. These bench marks were for the most part spikes driven into the roots of large trees.

Property surveys were made covering the area needed for each reservoir, and, although only parts of the farms were required, the whole farms were surveyed. Traverse lines from which the property lines and corners were located were run around each parcel of land and these traverse lines tied to the triangula-

tion stations. At the Nepaug basin 60 parcels, covering 2 466 acres of land, were surveyed, and at the East Branch basin 51 parcels, covering 1 683 acres. To determine the actual amount of property needed for each reservoir, the flow line of the reservoirs was staked out on the ground with stakes located about 100 ft. apart and standing up above the ground 2½ ft. The flow line of each reservoir measures about 11 miles in length. The water surface of the Nepaug Reservoir at elevation 485, the flow line, covers 851 acres, and the water surface of the East Branch Reservoir at elevation 422.5, its flow line, 437 acres.

A topographical survey was made at each of the two reservoirs with transit and stadia, and maps were plotted with horizontal scale one inch equals two hundred feet and five-foot contour intervals. From these maps the approximate capacities of the reservoirs were figured. The traverse lines for the stadia surveys were tied to the triangulation stations and to the property survey stakes. At each reservoir the stadia surveys covered areas around the reservoirs for about fifteen feet in elevation above the flow lines. In flooding the areas for the reservoirs, a number of highways were necessarily submerged, so that new highways had to be built to take the place of the ones discontinued. This required numerous topographical surveys over prospective routes, to determine the best and most economical ones to adopt. At the Nepaug Reservoir, 4.3 miles of new highways were built, and at the East Branch, 3.0 miles; 7.0 miles and 5.8 miles were discontinued at the Nepaug and East Branch reservoirs respectively. The field parties making stadia and property surveys usually consisted of an assistant engineer, an instrument man, and two rodmen. Except at the beginning of the work, when there were three field parties, two parties made all the surveys and gave all lines and grades when construction work was in progress.

The dam sites were tentatively located on the ground, and each site was then cross-sectioned and enough elevations taken to plot contours at two-foot intervals. At the Nepaug Reservoir there were three dam sites, — the Nepaug at the north end, the Phelps Brook at the south end, and the East Dike at the northeast end. At the East Branch two sites were cross-sectioned for study, located about 2 000 ft. apart. To finally decide on the best possible

locations for these dams, diamond drill borings were put down at each site and the depth to rock and the character of the rock penetrated determined. At the Nepaug site, 15 holes were drilled; at Phelps Brook, 6 holes, and at the East Dike, 4 holes. At the two sites on the East Branch, 23 holes were drilled. Besides the drill holes, test pits, varying in depth from 5 to 29 ft., were dug, to determine the character of the material overlying the rock and to locate suitable materials for concrete and earth embankments. At the Nepaug 73 pits were dug, and at the East Branch 52 pits. The field parties located all borings and pits, and these were plotted on the contour plans of the dam sites and the information regarding them noted.

The construction work at the Nepaug Reservoir was completed under seven main contracts, the Nepaug dam, the Phelps Brook dam, the East Dike, the Clear Brook road, the Nepaug road, and two contracts for clearing the reservoir site. The engineering work for these contracts was handled by two field parties of four men each, with engineering inspection on each contract. The two large dams were started about the same time with a field party located near each dam; the party at the Nepaug dam looked after the East Dike and the clearing contracts, and the party at Phelps Brook dam looked after the two road contracts. The Nepaug dam required the most attention as regards line and grade, as it is built on a curve with the upstream face vertical, the non-overflow section of the downstream face on a vertical curve, and the overflow section, a series of steps. It was built in radial blocks with expansion joints between them, about 40 ft. long on the center line, which was on a curve with a radius of 390 ft. A tower, 40 ft. high, was erected over the center of this curve, on which a transit could be set and the lines of the expansion joints given. There were 14 blocks in all, and the lines and grades of each were figured as separate problems. It required all the time of an assistant engineer to keep computations ahead of the points, as they were needed by the carpenters building forms. For giving points, a set of rectangular coördinates was used in conjunction with the expansion joint lines set from the tower. To hold the coördinate lines and the expansion joint lines, concrete piers were set in the ground, and bolts with crosses on them concreted in the

piers at the intersections of these lines. There were 28 of these piers built.

Copper bolts for bench marks were set in the concrete on the top of each spillway step, as the work progressed, and the elevations carried up on them. Besides the work of laying out the dam, the forms had to be checked after they were erected, before the concrete was placed. Each month, estimates of quantities of work done had to be made for payment to the contractor, and the measurements for these estimates and the calculations of quantities required considerable time.

The Phelps Brook dam was built on a compound curve in order to locate the core wall on ledge where it showed at the highest elevation at the dam site. The lines and grades were given on rectangular coördinates, however, and the differences in the slopes of the embankments, due to the curves, were figured on these coordinate lines. This system simplified the field work greatly. The East Dike and the dam at the East Branch are both straight, and the giving of lines and grades was comparatively simple.

Besides the seven main contracts for the Nepaug reservoir there were five other contracts connected with the work which required engineering attention, three for moving cemeteries and two for building a filtration plant for the Collinsville Water Company. Three main contracts have been let for the work at the East Branch Reservoir, — the Richards Corner dam, the Barkhamsted road, and the East Branch Highway Bridge. The engineering work at the East Branch Reservoir is being handled by the field party from the Phelps Brook dam, as the latter was finished about the time the former was started.

On November 29, 1916, the gate at Phelps Brook was closed and the basin allowed to fill. On December 23, the gate at the Nepaug dam was closed. The water in the Nepaug basin reached the divide between the two basins first on March 29, 1917, and flowed into the Phelps Brook basin. Both basins reached the same elevation on April 2. While the basins were filling, different contour intervals were located by transit and stadia distances to the water's edge from permanent stations set around the reservoir just above the flow line. This work was done to obtain an accurate figure for the capacity of the reservoir, and was carried on in

the winter months, when there was no construction work in progress.

DISCUSSION.

MR. HOMER R. TURNER. I should like to inquire if, in making the property surveys, the traverse lines were run by steel tape or stadia measures?

MR. HORNE. Tape measures.

MR. FRANK L. FULLER. I should like to inquire your practice in the stripping of these reservoirs. It occurs to me also that in doing this topographical work you must have had a pretty good opportunity to check up the government map, and I should like to ask how well that agreed.

MR. HORNE. There was no stripping of the reservoir. The trees were all cut down even with the ground, and on a strip of fifteen feet elevation around the edge of the reservoir the stumps were all blown out. There has been no stripping. On the topographical survey we found that the government maps were not particularly good in that locality.

PRESIDENT SAVILLE. In reference to the last statement, — that the topographical maps were not very good, — I should like to make an explanation, because I happened to be very intimately acquainted with that particular thing. The late Professor Shaler was the father of the topographical survey in the United States. He was professor of geology in Harvard, and much interested in the Lawrence Scientific School, a department of Harvard University. With the far-seeing knowledge of the necessity of a topographical survey of the United States, Professor Shaler got a very small appropriation to do some topographical work and sent a survey party out from the Lawrence Scientific School to do it. That topographical work was first undertaken right in the quadrant around Hartford, right here in Connecticut, and the fact that it is so poor is due to the very small appropriation that was made, to the lack of knowledge of topographical work, and to the fact that young men who were not the expert topographers that the United States Geological Survey has to-day were put on the work. The fact that it is as good as it is I think is a remarkable comment on Professor Shaler's work. That work will un-

doubtedly have to be done over again, but it has stood excellently as a prototype for the excellent work of the present geological survey. That is the reason this work is so poor in Connecticut.

MR. FRANK L. FULLER. I should like to ask if this base line was measured with a steel tape, or whether it was checked from the topographical work. The base line which I think was eight or ten miles long.

MR. HORNE. It was checked up with a local base line.

PRESIDENT SAVILLE. It was the side of one of the primary triangles. We used as a base line the side of a primary triangle of the Geological Survey.

MR. FULLER. Didn't you have to establish stations?

PRESIDENT SAVILLE. We established stations and then worked up our triangulation from the base line, which was the side of the primary triangle of the Geological Survey, and in that way we did not have to go to the refinement of measuring the base line ourselves.

THE DESIGN OF THE DIVERSION CONDUIT AND WASTE WORKS OF THE RICHARDS CORNER DAM AT NEW HARTFORD, CONNECTICUT.*

BY R. E. WISE, DESIGNING ENGINEER.

[*Read September 13, 1917.*]

The Richards Corner Dam, which is being built by the Board of Water Commissioners of the city of Hartford, Conn., is to store the flood waters of the east branch of the Farmington River, and the stored waters will be let flow down the river during periods of low water in the river, to compensate in kind the mill owners, on the Farmington River below, for the diverted waters of the Phelps Brook and Nepaug River, the flows of which have been taken for the new water supply of Hartford.

This paper will deal with the design of the diversion works of this dam, namely, the stream control conduit, the spillway, and waste channel.

One of the first and most important problems that confronted the engineers in planning the construction of this earth dam was the method of taking care of the flow of the river during construction. The watershed of this river above the site of the dam is about 61 square miles, being long and narrow, — about 16 miles long by 4 miles wide, — with steep and rugged side slopes, which produces a flood condition quickly after a storm. To protect the foundation work which was to be carried 50 ft. or more below the bed of the river and the dam itself until completed, a concrete conduit was designed with such a carrying capacity that it would discharge any flood flow that it was thought might come during the period of construction of the dam. In studying probable flood flows of this river, records of rainfall and run-off flows were only obtainable back to March 1, 1912, at which time the Water Board of Hartford began taking records. Since that date two

* The engineering work of this dam is under the direction of Caleb Mills Saville as chief engineer, with Frederic P. Stearns and John R. Freeman the consulting engineers, and the writer in charge of the designing division.

large flows have been recorded, the maximum on February 25, 1915, on which date 2 to 2½ in. of rain fell in eighteen hours, producing a maximum run-off of about 52.5 cu. ft. per second per square mile, the crest of the flood being reached about eight hours after the beginning of the storm. There was a small amount of snow on the ground, which had been softened by several days of warm weather. The run-off from this storm was 1.8 in. on the watershed, about 80 per cent. of the rainfall. The other flood recorded was on October 26 and 27, 1913, 5 to 6½ in. of rain falling, which produced a maximum run-off of 44.5 cu. ft. per second per square mile, the crest of the flood being reached fourteen hours after the beginning of the storm. Recorded flood flows of other rivers were studied, and one in particular may be noted, — that of the Nashua River at the site of the Wachusett Dam on February 13, 1900, at which time 3.2 in. of rain fell with ice on the ground, and produced a maximum run-off of about 80 cu. ft. per second per square mile, the crest being reached eleven hours after the beginning of the storm. The drainage area on this river is nearly twice as large as that of the East Branch, and it contained quite a large number of swamps and ponds which would tend to store water and help mitigate the floods. With the above data at hand, it was thought that a conduit which would pass 100 cu. ft. per second per square mile of watershed would safely provide for any flood liable to occur during the period of construction.

Considerable study was given to the location and alignment of the conduit. Borings taken along the east bank of the river indicated a sharp shelving off of the rock surface. A study was made for a location to effect economy in construction, minimum length, and excavation, by constructing the conduit on a 400-ft. radius which would place the central portion well into the hill, and a good rock foundation for this portion would be assured. This would have involved building partly on rock and partly on earth toward the ends. A straight-line alignment was finally decided upon, with a location well into the bank in order to secure, if possible, a rock foundation throughout the entire length of the conduit.

To divert the flow of the river to the conduit, a cofferdam of

earth was placed across the stream at the head of the conduit. This dam was carried to a height of 15 ft. above the crown of the conduit and forms a basin above, which when at a level sufficient to make the conduit discharge 100 cu. ft. per second per square mile of watershed would contain 250 million gallons, or about 0.4 in. of rain over the entire watershed. The ponding effect of this basin would be to delay the crest of a flood caused by a 100 cu. ft. per second per square mile of watershed run-off to eighteen hours after beginning of storm if the rate of rise was approximately that of the floods noted on this river and the Nashua River.

To divert the normal flow of the river to the entrance of the conduit, it was necessary to excavate a diverting channel about 6 to 8 ft. deep, 20 ft. wide at the bottom, with side slopes of 1 on 2. To reduce the seepage under the cofferdam to the core wall trench, of the water from this channel, the bottom and sides were lined with 9 in. of loam, over which was placed a layer of gravel 6 in. thick, to prevent scouring the loam.

A great deal of study was given to the design of the entrance to the conduit. It was realized that the maximum discharging capacity could be secured only by careful attention to the shape and finish of the bell-mouth entrance to the conduit, because cross currents, eddies, and surges must be avoided. It was thought that the bell-mouth should be symmetrical in horizontal cross-section out to a point where the velocity becomes fairly slow, which point was estimated to be where the width of the entrance was fully double that at the throat of the bell-mouth. The sides of the flaring walls to the entrance of the bell-mouth were made vertical at the tunnel entrance, and made to pitch back to a generous batter in a sort of warped surface out to the ends. These side walls were carried out at an elevation above the estimated flood flow line of 100 cu. ft. per second per square mile of watershed, to a distance equal to the width of the tunnel entrance, so that water approaching from the side would not tumble over them and disturb the smoothness of the flow at the entrance.

The bottom of the bell-mouth was founded on earth, as the rock foundation shelved off at the entrance to the conduit. This bottom was excavated to a depth of about 18 in., refilled with

loose broken stone, and smoothed over with a lean mixture of concrete.

The invert of the conduit was carried out to a point 10 ft. beyond the mouth, and was curved in order to make it more stable against an upward pressure which would be caused by the difference between the upward pressure due to the height of the water in the pond above the conduit and the downward pressure due to the height of water above the invert, which would be less than the pond elevation by the loss of head at entrance.

The transition at the entrance to the conduit from an approximate square with 21 ft. sides to the standard horseshoe section of the conduit was made in 25 ft. The standard section of the intrados of the conduit is of the typical horseshoe shape, and is 21 ft. wide and 17 ft. high, having an area of 279 sq. ft. The total length of the closed conduit is 315 ft., with expansion joints placed approximately 30 ft. apart. At these expansion joints are imbedded 6 in. by $\frac{3}{8}$ in. ingot iron water stops, extending entirely around the section. The strength of the conduit section was varied to meet the different imposed loads through the dam by changing the extrados, three different sections being used. To prevent a flow of water following along the outside of the arch, water stops were built about 10 ft. on centers for a distance of 100 ft. below the core wall.

As there is to be a gate well built into the conduit in the upper portion, at the completion of the dam particular attention had to be given to the strength of the invert of the conduit below this point on account of the upward pressures that might come upon it. The conduit below this gate well will be empty after the completion of the dam, and the full pressure from the water in the reservoir may be exerted beneath the invert. For a distance of about 40 ft. above and below the location of the core wall, the rock beneath the invert was drilled and grouted and the maximum thickness of the invert was carried along this distance. As there would be a diminishing upward pressure below the core wall, the invert was made thinner below the grouted portion, and drill holes were made through the invert of this portion to assure no upward pressure.

At the outlet of the conduit the retaining walls were flared

slightly and the apron between them built with a descending grade, hoping thereby to secure the effect of a divergent Venturi tube in diminishing the velocity of the water.

At the completion of the dam there will be built in the conduit, 30 ft. above the location of the core wall, a gate well containing two 3 ft. by 5 ft. sluice gates, which will be operated to pass the water from the reservoir to the stream below as the requirements of the mill owners below demand. After the installation of this gate well in the conduit, at the downstream end of the tunnel, will be built a concrete curtain wall with an opening heavily barred, the idea being to prevent some crank with a box of dynamite from walking up the conduit and firing it off close to the two outlet gates.

To discharge the flood waters after the completion of the dam, a spillway or waste weir is located on the west bank of the reservoir where rock outcrops and test pits indicated ledge rock near the surface. The waste weir will have a total length of 290 ft., and is carried upstream at right angles with the dam at its west end. This weir provides for a discharge of 10 000 cu. ft. per second under a 5-ft. head, which is equivalent to a rate of 163 cu. ft. per second per square mile of watershed and would discharge a flow of 200 cu. ft. per second per square mile run-off with a 5.6 ft. head. This run-off of 12 200 cu. ft. per second would make the water stand in the upper end of the waste channel two or three feet above the crest of the weir, and the pond elevation would be from 6 to 7 ft. below the top of the dam. The weir will be founded on rock throughout its entire length, and built of concrete with its crest $12\frac{1}{2}$ ft. below the top of the dam and rounded on its downstream side sufficiently to cause the water to follow the masonry. Below the rounded crest, at the surface of the rock, will be a 10-ft. beam, 5 ft. of which will be covered with concrete, to receive the impact of falling water. The section of the waste weir has a wide base which ought not to slide or overturn. Bronze sockets for flashboard pins will be spaced about 10 ft. on centers along the crest, for the possible use of flashboards.

For the waste channel a rather favorable location exists, in that the surface of ledge rock was of moderate depth to a distance

below the dam where the discharging water would not affect the integrity of the dam by flowing in an earth channel. The waste channel runs approximately at right angles to the dam, and is to be excavated into the rock to a point far enough below the center line of the dam to prevent any danger of wrecking the main structure by overflowing the rock channel, and it is of such section — 25 ft. to 35 ft. width at bottom with 4 on 1 side slopes — that retaining walls will be unnecessary. It was thought desirable to excavate into the rock for the portion opposite the waste weir and opposite the end of the dam only enough to keep the water from rising too much above the crest of the waste weir in the event of a flood of 200 cu. ft. per second per square mile run-off. At a distance 90 ft. below the center line of the dam, a steep grade (9½ per cent.) was given to the channel, to greatly accelerate the velocity of the water and reduce its level and to continue to keep within the rock channel to a point approximately 300 ft. below the center line of the dam, where even in the case of a great flood the damage done by the water flowing over the sides of the rock channel beyond this point could not affect the integrity of the dam. At about 350 ft. below the center line of the dam, the rock surface disappears below the bed of the channel, and at this point the grade of the channel changes from 9½ per cent. to 1.3 per cent., and the channel is wholly in gravelly material until it reaches the river 500 ft. beyond. This earth channel is to be a rough steam shovel cut approximately 10 ft. deep and 30 ft. wide at the bottom, with rough shaping of the side slopes. It is expected that great floods will cause washouts along this part, but such damage will not affect the dam, and it was thought better to take the risk of such damage along this part than to incur too much expense in the construction of this portion of the waste channel.

Discussion.

Mr. Frank L. Fuller. As I understand it, this waste conduit is a prominent part of the construction. Is it not so?

Mr. Wise. Yes, it is.

Mr. Fuller. Well, I don't exactly understand how that was closed, — the form of gate that was used to close this conduit.

Mr. Wise. Just above the core wall is to be a gate well built

into the conduit in which there are two 3 by 5 sluice-gates. These gates will be kept closed until they are opened to pass the water down the conduit to the river below as the mill owners demand. During the spring there is plenty of water in the other branch of the river, and the mill owners will not want this water. Then in the summer, when there are low flows in the other river, we will let the water out from this reservoir through these gates into the conduit, which will pass the water into the river down to the mill owners below.

MR. FULLER. Would this conduit be used to aid the spillway in the time of an excessive flood?

MR. WISE. Why, it could be used. We don't think it will be necessary. We think we have provided a sufficient spillway to take care of any flood we think possible to come.

MR. ———. Will any provision be made for the utilization of power from this dam?

PRESIDENT SAVILLE. None. It might perhaps be interesting to say, in relation to this, that this is one of the few, if not the only case, of legal compensation in kind. This is the case for this particular reservoir: The legislature gave the Water Board of Hartford authority to take this and to compensate the mill owners, but several of the property owners claimed that, while the legislature had a right to allow condemnation for water-supply purposes, this was not a water-supply purpose but, as they claimed, a way for the city of Hartford to avoid payment of damages, therefore not constitutional. The case was carried up to the United States Supreme Court and decided in favor of the city of Hartford, and it therefore formed rather a valuable example for cases of similar character later.

MR. FULLER. Then, do I understand, Mr. President, that the mill owners have some claim on the water?

PRESIDENT SAVILLE. The mill owners have every claim. This reservoir is entirely built for the use of the mill owners. The city of Hartford has no rights in it as a water-supply proposition. It will be operated at the expense of the city of Hartford, but at the behest of the mill owners as they desire this water. And the probability is that once, at least, or perhaps twice during the year, the water may be entirely drawn out of this reservoir, — it may

be entirely emptied, because it is for compensation purposes pure and simple.

MR. HIRAM A. MILLER. Doesn't that destroy the value of this for water supply for the city? The time when the city will want this water is when there will be a low flow, and that is the time the mill owners will want this water.

PRESIDENT SAVILLE. The present development is thought to be sufficient for the next thirty-five or forty years. In order to get the supply which we definitely needed at once, we were content to let that question rest until the future, for the next generation to settle.

MR. FULLER. That is, it is possible that this, later on, might be called into use as a supply for the city?

PRESIDENT SAVILLE. That has not been considered.

MR. MILLER. In regard to the compensation in kind, I should like to inquire if the mill owners assented to this being paid in this way, or if they went to the courts and got a decision in their favor.

PRESIDENT SAVILLE. There were three different ways in which this thing was handled, — three different ways of looking at it by the mill owners. As I said in the beginning, all of the mill owners, practically, are very favorably disposed toward the city of Hartford. That was the basis on which the thing started. The largest mill owners, the ones that own a majority of the total water-power privilege on the Farmington River, signed an agreement with the city of Hartford that they would accept this method. That is, they signed it tentatively. They would accept it provisionally. They would withdraw their opposition. They did not, however, give up all of their rights to a future claim if they considered it necessary to make it. Another portion said they would not sign any agreement, but if they found they were not damaged as to the amount of water that was flowing, there would be no claims; and there probably will not be. The third portion, which was a very small minority, held the position that they would reserve all their rights in every way.

MR. FULLER. Is the quality of the water of these three different reservoirs essentially the same?

PRESIDENT SAVILLE. Essentially the same; yes, sir.

THE CONSTRUCTION OF NEPAUG DAM.

BY H. W. GRISWOLD, ASSISTANT ENGINEER.

[*Read September 13, 1917.*]

Contract No. 5, for the construction of a masonry dam and appurtenances, together with about one-half mile of highway in the towns of New Hartford and Canton, Conn., was awarded to Fred T. Ley & Co., Inc., of Springfield, Mass., in March, 1914, and was completed by them in July, 1917.

The dam was built largely of cyclopean masonry, with a maximum height above the surface of the rock of about 130 ft. and a length of 600 ft. In section, it is 20 ft. wide at the top, 90 ft. at the bottom, and is curved upstream to a radius of 390 ft. An overflow section was built in the center of the dam, the highway being carried over it on a series of 5 concrete arches, each having a span of 36 ft. The overflowing water falls down a series of steps into a pool lined with concrete, rubble masonry, and paving, at the base of the dam. The difference in elevation of the surface of the water in this pool and that in the reservoir is 100 ft. An inspection gallery, 7 ft. by 5 ft., entered from the lower gate chamber, runs parallel with the axis of the dam near the upstream face, and from this gallery seepage wells are carried down to rock and up to reservoir flow line.

For the transportation of material and supplies for construction, it was necessary to build a mile of standard-gage railroad up the Nepaug Ravine to the dam site from the New Hartford Branch of the New Haven Railroad. The grading for this spur was done with a $\frac{3}{4}$-yd. steam shovel, and a portable boiler and steam drill for the rock work. As soon as steel was laid on the spur, a commissary and bunk house of the usual type were built, and the construction of the cofferdams and flume begun.

The upper cofferdam was about 150 ft. upstream from the axis of the dam; the lower, 175 ft. downstream from the axis; and both were of the rock-filled crib type, with tongue and groove

sheet piling and toe fill on the river side. The flume was built along the foot of the west slope and was framed and planked as suggested on the contract drawings. This flume was removed as soon as the two central blocks of the dam were built above the river bed, and thereafter the river was diverted through a 10 by 10 ft. culvert in one of these blocks with a flume from the downstream face to below the lower cofferdam. In filling this culvert with concrete, after the dam was completed, the part between the upstream face and the inspection gallery was first poured, the water being carried around this section in a small by-pass which had been left in the concrete. This by-pass was next filled, and then the remaining section downstream from the inspection gallery was poured and the whole closure grouted to insure watertightness.

Excavation was started with the steam shovel as soon as grading for the spur track was finished, the excavated material being hauled by train to a spoil bank in a side valley about one quarter mile below the dam site. Earth at the top of the east slope was hauled by team to spoil bank below the dam, and material (largely sand) on the east slope was sluiced down to the steam shovel below with a fire hose. The same method was tried on the west slope, but was not successful, and the excavation there was completed with pick and shovel.

The underlying rock, a mica schist with numerous pegmatite dikes, had a dip of 45 degrees to the west, so that the east slope showed comparatively smooth ledge, while the rock on the west slope was very irregular. Just east of the river was a ridge of fairly sound rock, and between this and the foot of the west slope, under the bed of the river, was an area of hydrated mica schist, which had the unpleasant characteristic of disintegrating into a sort of blue mud, on exposure to the air in the presence of water.

Practically none of the dam is built on the original surface of the rock, it being necessary to excavate from 2 to 30 ft. before rock suitable for a foundation could be found. The upper part of this excavation was done by drilling and blasting, and the balance by barring and wedging. Spoil was handled by derricks and skips into cars.

A suitable foundation being secured, the next step was to make

a watertight cut-off in the rock, 10 to 20 ft. wide, near the upstream face, by forcing grout under pressure into the seams of the ledge. That a practically watertight cut-off was secured for the full length of the dam is shown by the very small leakage through the seepage wells with the reservoir within six feet of being full.

The method of laying out the work is of special interest, as nearly every surface of the dam is curved in at least one direction. The upper part of the downstream face of the non-overflow section is curved both vertically and horizontally. The method used, which worked out very successfully, was devised largely by Mr. G. W. Penfield, who was in charge of the field party, and consisted primarily of a dual system of rectangular and polar coördinates. The origin of polar coördinates was at the center of the sweep of the dam, the axis of which was curved to a radius of 390 ft., and over this point a 40-ft. tower for a transit station was built. A base line was run up the valley from this tower and a second base line, with concrete monuments at either end, was run at right angles to the first and tangent to the axis of the dam. From these base lines the rectangular coördinate system was extended as needed. All monuments were set by rectangular coördinates and checked by triangulation, the monuments at the ends of the east and west base line and the origin of polar coördinates forming the primary triangle. In laying out face forms, the expansion joint lines on either side were first given from the tower, and the intersection of the face form with these lines obtained by measuring a computed distance along the expansion joint lines from their intersection with an east and west rectangular coördinate line. Curve of form between expansion joints was given by ordinates from the eighth points of a chord, formed by pulling a line between the points on the expansion joints. Batter and radius boards were also used in checking and truing up forms.

In general, forms were built of 2-in. lagging, with 2 by 6 studs on 2-ft. centers, and 4 by 6 rangers. To save time in erection, lagging was cleated into panels 8, 10, and 12 ft. long. Forms were wired to plum stones or pins set in concrete.

The cement used for concrete work was tested at the mill and

on the job. Storage was provided for 60 cars or 10 000 bbls. Crushed trap rock was shipped from the quarry at Tariffville in bottom-dump, steel gondolas, from which the stone was dumped directly into the bins. Bin capacity was 2 000 cu. yd. stone and 1 000 cu. yd. sand. . Sand was obtained from a glacial deposit in the valley used as a spoil bank, and stone for plums and heavy riprap was quarried in the same valley. Bowlders, picked out of the river with a locomotive crane, were also used for this purpose.

Concrete was mixed in two 1-yd. Ransome mixers, served by skip cars running in a tunnel under the bins. There was a wooden tower for each mixer, but both towers dumped into the same chute. Chutes were suspended from derrick guys, or cables put up for that purpose.

The method of placing concrete in the form was a new wrinkle which worked very successfully. It consisted of bringing the end of the main chute to a 30-ft. gin pole, fitted with two horizontal booms with a swinging radius of about 270 degrees. The upper boom was about 20 ft. long and the lower 10 ft. long. By suspending two 10-ft. sections of chute, one from the end of the main chute and the tip of the lower boom, and the other between the lower boom tip and a trolley running along the upper boom, concrete could be placed at any point within the swing of the upper boom. A 3-ft. square box was built around the gin pole, and the resulting hole in the concrete was filled up the next time concrete was poured in that block.

Before placing concrete on the rock foundation, the latter was washed perfectly clean with a hose stream, all loose rock removed, and the whole surface covered with grout, put on with a fire hose under about 80 lb. pressure. It was then plastered with mortar which was worked into all large cracks and holes.

The surface of each day's run of concrete was broomed or scraped with hoes the morning after it was laid; and, before fresh concrete was placed, it was thoroughly washed and broomed with grout. A crushed stone drain was laid between seepage wells to intercept seepage on a day's work joint. The expansion joint seepage wells were closed with concrete blocks, and the whole surface plastered with mortar; 1:3:6 concrete was then placed

in 1-ft. layers, beginning at the downstream face. Along the upstream face, a richer misture (1:3:5) was used for a width of about 3 ft. No drawboards were used. Plum stones were cleaned with a hose stream on the cars, and placed by derrick. In forms where chutes could not be used, concrete was placed with 2-yd. Haines buckets. About 375 cu. yd. was an average day's work with chutes, and bulkheads were built where necessary to give a depth of 6 to 8 ft. for a day's work.

In addition to the plums which stuck up above each lift, a key 6 in. deep by 3 ft. wide was left at the upstream face, and usually a section 4 to 6 ft. wide along the downstream face was left 6 in. higher than the rest of the run.

Sidewalks, the roofs of the gate chambers, and tops of parapet walls were trowel finished; spillway steps were floated, and sides of parapet walls and all panels were rough pointed. The downstream face of the non-overflow portion was sand blasted.

The cost of the work was approximately half a million dollars, and the following is a list of the principal items:

Earth excavation	35 000 cu. yd.
Rock excavation	20 000 cu. yd.
Refilling and embanking	17 000 cu. yd.
Cyclopean masonry	75 000 cu. yd.
Mass concrete	4 000 cu. yd.
Concrete surfaces finished	40 000 sq. ft.
Portland cement	80 000 bbl.
Large cast-iron pipe and special castings	40 tons
Metal for reinforcing concrete and for waterstops	100 000 lb.
Miscellaneous cast iron, wrought iron and steel	35 000 lb.

Discussion.

Mr. Frank L. Fuller. I should like to ask where the concrete was started from the rock, — whether the surface of the rock was leveled off, assuming that it was sound and in good condition but was not exactly level, — rounding, perhaps.

Mr. Griswold. I don't think there was a level place on the whole dam site.

Mr. Fuller. Well, was that leveled off into steps, or otherwise?

MR. GRISWOLD. It came out naturally in rough steps. It pitched down at about 45 degrees, and if you broke one lip and removed it, it left a step.

MR. FULLER. So that but little hand work had to be done?

MR. GRISWOLD. In stepping the rock; yes, sir. There was quite a little hand work in cleaning out the cracks, and so forth.

MR. FULLER. Did that leave a sound rock surface? Were these steps as you applied the concrete to them all sound and in good condition?

MR. GRISWOLD. As sound as could be expected, yes. That is, by testing with sledge hammers. Anything that was loose or could be broken off was removed.

GROUTING OF THE ROCK FOUNDATIONS OF THE DAMS OF THE ADDITIONAL WATER SUPPLY OF THE CITY OF HARTFORD.

BY J. E. GARRATT, OFFICE ENGINEER.

[*Read September 13, 1917.*]

To one of an inquiring and imaginative turn of mind, no part of the work connected with the building of Hartford's additional water supply is perhaps more interesting than the testing and grouting of the rock foundations on which its three large dams are located. At least the person actually performing the work has every opportunity to use all of such faculties that he may possess.

At each dam the main object of the testing and grouting of the rock foundation has been the same, — the making of one continuous section of the rock entirely tight to the passing of water, from end to end of the dam, and for a depth of 25 ft. into the rock. This "cut-off section," as it might be called, was located at the upstream edge of the Nepaug masonry dam and under a 10-ft. concrete apron on the upstream side of the concrete core walls of the Phelps Brook and the Richards Corner earth dams.

The problem of one tight section has been attacked in the same general manner at each dam. Two rows of drill holes, 25 ft. deep, with rows about 5 ft. apart, and with holes 15 ft. apart in the rows, and staggered, were first drilled. These holes were tested at various depths with water under pressure. The leakage was measured and careful observations were made of the location of seams, the interconnection of holes, the appearances of water at surface seams, etc. The amount of water pressure was always well above any which would be developed later by the water ponded against the dam. On the strength of this testing, the rock seams intersected by the hole could then be tightened by forcing grout into them.

If a hole was tight, no grouting of it could be done, of course, nor was it necessary. Such holes were poured full of mortar.

If a hole showed very small leakage, a thin grout could be used at once. If the leakage was considerable, a thick grout could be used to start with. If there were large leakages from a hole near its top, which indicated loose, seamy rock, grouting could be postponed until this rock was removed or until concrete was placed over the rock in the vicinity.

When this first group of holes had been completely grouted, other holes were drilled of various depths, depending upon the depth of leaky, seamy rock as shown by the first testing. These holes were located between the two rows of primary holes. They were then tested to show the results of the primary grouting. If they were tight, no further grouting was done. Depending upon the amount and the location of leakage and the amount of grout required to tighten such of these holes as needed grouting, other holes were then drilled, tested, and grouted, and this operation repeated until there was absolute certainty of the tightening of any seams of consequence in the area between the two rows of primary holes. As a rule, the grouting was completed with primary holes and secondary holes between. At places, however, where large seams or unusual conditions were encountered, as many as four sets of holes were drilled, tested, and grouted.

So much for the general scheme of the work. In the actual carrying out of the work at these dams, each case differed somewhat in the details, because of the character and the configuration of the rock.

At the Phelps Brook Dam (where the first grouting was done), the rock was a mica schist, set practically up on edge, without well marked bedding plane seams but with seamy areas striking across the dam at an angle of about 45 degrees to the center line. At the extreme southerly end of the dam the rock, as it originally laid, outcropped for about 200 ft. At the north end of this section there was a 30-ft., nearly vertical rock face. This rock wall was found, upon excavating, to continue 30 ft. more below the original ground surface. At its foot was a seam of green hydrated mica schist at a fault plane between the high rock at the south end of the dam and the low rock to the north. This low rock was found at a general level of about 30 ft. below the original ground. It continued for about 150 ft. to the north, where it quickly stepped

up to the original brook bed. From here towards the north was a ridge of apparently hard, sound, outcropping rock, which, 250 ft. on, suddenly disappeared again and was found to be about 20 ft. below the surface. From the north edge of this low-lying rock, of which there was about 70 ft., the rock rose quickly, outcropping for the most part, for a distance of 300 ft. to the north end of the dam. There were two deep excavations to the rock surface, one near the south end of the dam and one near the north end of the dam. Between them was a ridge of high, hard rock which originally outcropped: At each end of the dam the rock was high and also outcropped.

Grouting was started at the Phelps Brook Dam in the late summer of 1914 and was completed in the spring of 1916. The first grouting was done at the deep excavation near the south end of the dam. No surface rock was removed, as it was smooth and hard and apparently sound. Tests of these holes showed no large deep-seated leakage, although the upper portions of the rock were found to be quite full of seams. Attempts to grout these holes with 60-lb. air pressure loosened portions of the surface rock in places, and the grouting of the primary holes was completed only after the concrete apron was placed over all of the rock in which they were drilled. Even then comparatively large quantities of grout were wasted in efforts to stop surface leakage and blow-outs. When secondary holes were next drilled and tested in this location it was found that there was a large, deep-seated seam which took water away in considerable quantity and through which the same water came back under several feet of head. Large quantities of grout were required to tighten this seam, and none of the grout appeared at points other than adjacent grout holes. Proof holes next drilled still showed some leakage, but only small and deep down. They were grouted with but little grout and the rock was considered properly tightened.

At the southerly end of this deep excavation there was an almost vertical rock wall. At the foot of this wall was a 30-ft. seam of soft green hydrated mica schist. There had been a fault or a slip in the rock at this point at some time. Holes in this hydrated rock were practically tight, but the rock was so weak when not confined that grout pipes could not be held in the tops of the

holes, and grouting was completed only after concrete was placed over the rock.

As it was the natural desire of the contractor to fill both deep excavations before the end of the first season, the next grouting was in the excavation at the north end of the dam. Although the rock in this hole was a seam of apparently none too sound rock, it was thought that it would be cheaper to tighten it by grouting than to remove it. Attempts to tighten it, however, before any concrete apron was placed, loosened several feet of the surface rock, and the grouting was abandoned, while five to seven feet of the top poor rock were removed. Concrete was then placed over the remaining rock and grouting was completed through holes drilled into the rock through this concrete apron.

The high ridge of rock between these two holes was grouted the following spring and summer before any concrete was placed over it. Many of the holes drilled in it were tight throughout. From one hole in this rock, grout carried 40 ft. along a seam parallel to the center line of the dam and outflowed in the bottom of a 10-ft. trench in the rock.

The rock at the northerly end of the dam was, for the most part, sound and good and was grouted with little difficulty. At the extreme northerly end, the rock for a distance of 100 ft. was tight and only one row of drill holes, 15 ft. deep, was put down to prove this area.

No great difficulties were encountered at the south end of the deep southerly excavation in grouting the 60-ft. vertical rock wall there. Inclined holes 25 ft. deep were drilled in the rock face as the concrete core wall was brought up in 5-ft. lifts. These holes were grouted either before or after concrete was placed over the tops of them, depending upon whether there were not or were large seams near their tops.

South of this vertical rock wall the high rock at the south end of the dam was quite seamy near the surface. It was, however, grouted with no great amount of trouble and, generally, before concrete was placed over the holes. In the rock at the top of certain of them, to be sure, blow-outs occurred and blocks of rock a yard or more were loosened during the grouting attempts, but these loosened blocks were removed and the grouting then completed.

At the Nepaug Dam the rock was a mica schist with regular and marked laminæ dipping 45 degrees to the west and striking at right angles to the center line of the dam. Consequently the rock on the east side of the dam presented steep, smooth faces, that in the center was, in section parallel to the dam, saw-toothed, and that on the west side presented the ends of the laminæ only.

At the center section, considerable surface rock was removed at once before any grout holes were drilled. The rock was then tightened without much difficulty and with seldom more than secondary holes. At the foot of the steep slope at the west side of the valley there was a seam of hydrated mica schist, similar to that encountered at the south end of the Phelps Brook Dam, only black instead of green. The rock on either side of this seam was loose and seamy and was excavated to a maximum depth of 35 ft. In the sound rock finally reached, holes were drilled to thoroughly explore and cover this zone of fault and contact. The seam of hydrated rock was then quickly covered with concrete and the grouting was done through this concrete.

On the steep slope at the east side of the valley, grout holes were drilled for the most part in the hard, smooth, original surface of the rock. At several places the first grouting loosened large thin slabs of this surface rock, which were then removed. Below 5 to 10 ft. down, however, this rock was tight.

On the steep slope at the west side of the valley, explorations with a diamond drill hole and with a few grout holes showed that the surface rock was loose and seamy. So large amounts of rock were removed in places. Even then grouting could not be done until concrete had been placed over the rock. This was not due to any serious weakness in the final rock, but to the fact that the rock was set well up on edge and the grouting pressure would blow out through the seams at the top of the holes. Below a few feet down the rock was generally tight, and, with a mat of concrete to hold the grouting pressure, it was easily grouted. Several springs in the rock were encountered. These were piped through the concrete and grouted as any other grout hole.

At the East Branch compensating reservoir, Richards Corner Dam, in addition to making a tight section under the upstream edge of the core wall, this section is to be continued under the

spillway section at the westerly end of the dam. Also where the diversion conduit passed through the core wall, the rock which was to underlie the conduit was grouted for a distance of about 40 ft. above and below the core wall through three rows of holes 25 ft. deep. One row of holes was located under the center line of the conduit and one row 10 ft on either side of this one, which brought them near the outside edge of the conduit invert. No concentrated effort to tighten completely this whole section was made. The object of the grouting was to discover and tighten any seams of considerable size or extent which later might cause upward pressure on the conduit. The rock under the conduit was found to be a mica schist with intrusions of pegmatite dikes striking southeast-northwest about 45 degrees to the axis of the dam, which runs east and west, and dipping about 60 degrees to the southwest. In those areas where dikes were located, of which there were three, there were often large leakages and interconnections of holes 20 ft. apart.

In the area just upstream from the core wall, which was a portion of the section to be thoroughly tightened, efforts were concentrated, secondary and then tertiary holes were drilled, tested, and grouted, and the section surely tightened.

West of the diversion conduit, which is near the easterly end of the dam, the rock slopes downward very steeply. For a distance of about 60 ft. this rock was poor mica schist. Holes were drilled in it to test it out. Tests showed that it was quite weak and seamy at the top. Attempts were made to grout all of these holes with the idea, principally, of loosening the poor surface rock so that it could be removed easily. The grouting of them was completed some time later after the core wall had been brought up to the elevation of the rock here.

Working westerly from this section of poor rock, the rock was grouted in 30-ft. sections as it was uncovered and prepared for concrete. Drilling and testing was, of course, done before any concrete was placed over the section, but grouting was generally done after the concrete apron was placed. This was not because the rock was poor, but because water and slipping banks made it desirable to cover the rock as soon as it was once properly cleaned. About 200 ft. from the conduit the rock changed from

a mica schist to a hard gneiss. Holes in this gneiss were often tight. Near the zone of contact between schist and gneiss an open seam about 3 in. wide, nearly horizontal, and 15 to 20 ft. down, was discovered. This could be tightened only by pumping grout into it until it flowed freely from surface outlets and then allowing the grout to set in the wide seam. Other than this no great difficulties have been encountered in any of the grouting work here. The grouting is not completed.

Grouting Equipment.

At each of the three dams a Ransome Canniff grout mixer of 4.5 cu. ft. capacity was used for the grouting work. This machine mixes and discharges the grout by air pressure. At the Phelps Brook Dam a gasoline-driven air compressor was first used. This furnished an abundant air supply at pressures up to 80 lb. *when it worked.* But it was very likely to stop work in the midst of the operations of grouting an important hole. Mixer and connections would then plug, and often an hour would be lost in cleaning them out. More serious than this, from the grouting point of view, was the feeling that the grout already in the hole might have settled into the bottom and plugged there, thereby preventing additional grout from getting into seams not completely tightened. A small steam-driven Westinghouse air pump with a storage tank of 20 cu. ft. capacity was later substituted for this. This could furnish 60 lb. pressure at the most and could not be recommended for the work. At the Nepaug Dam a large steam-driven horizontal air compressor furnished an abundant air supply always at pressures up to 100 lb. At the Richards Corner Dam a large steam-driven Westinghouse air pump with storage tank of about 100 cu. ft. capacity furnished an abundant air supply at any pressure up to 80 or 90 lb. (provided it was furnished with the necessary supply of steam).

Grouting was done for the most part through pipes cemented into the tops of the holes. At the Phelps Brook Dam $1\frac{1}{4}$-in. pipes were used, and $1\frac{1}{4}$-in. flexible rubber hose connected mixer and grout pipes. This hose often plugged when holes were nearly tightened and the flow of grout became small. So a blow-off valve was attached to the end of the rubber hose. At the Nepaug

and Richards Corner dams, as a result of the troubles experienced at the Phelps Brook work, a 2-in. flexible grout hose was obtained and 2-in. pipes were used in the holes there. With grout pipes cemented into the holes it was always necessary to wait at least a day before putting pressure into the hole and often, during cold weather, pipes were blown out of holes after having been cemented in for two or three days. So, early in the Nepaug Dam operations, a grouting plug was rigged up. This consisted of a 2-in. pipe on one end of which was a rubber plug which could be expanded and tightened in the top of the grout holes. All holes which could be grouted before concrete was placed over them or which were not too irregular at the top were grouted thereafter through this grouting plug.

As found from our experience then, the most satisfactory accessories for a Ransome Canniff grout mixer are an abundant air supply from any source which is surely continuous, a 2-in. flexible pressure hose in 25-ft. sections for ease in cleaning if necessary; at the end of the hose a 2-in. tee with blow-off stopcock (no gate valve is satisfactory for this) on one outlet and a 2-in. union on the other for connection to a 2-in. grouting plug or to a 2-in. grout pipe cemented into the grout hole.

Practical Points in Actual Grouting Operations.

Following is a general idea of the consistency of the grout used in our grouting operations.

1. With small leakage from a hole, say 0.5 cu. ft.[1] per minute or less, in order that grout will carry along small seams, one bag of cement is added to a mixer full of water, which gives a grout of about 1 : 4.

2. With moderate leakage, say 0.5 to 1.0 cu. ft. per minute, a grout of 1 : 2.5 is used.

3. With large leakage, say 1 to 2 cu. ft. per minute, a 1 : 2 grout is used for three or four charges and then sand in increasing amounts is added in efforts to plug the seam.

In poor rock, care must be taken to close off the mixer as soon as a charge is emptied, so that air will not get into the hole and into the rock seams and blow up the surface rock.

When grouting holes with small leakage, the blow-off valve at

the hole end of the hose should be opened at least every three minutes to prevent the grout from settling and plugging the mixer or hose.

With sand in the grout, the air must be kept boiling up through the grout until just the moment that the charge is turned into the hole.

Consequently, none but the best intelligent labor should be used on this work, as delays due to plugged hose and mixer and surface blow-outs are costly and prevent the most effective grouting of the holes.

If large surface blow-outs occur, it is futile to continue the attempt to grout a hole to refusal. If no concrete has been placed over the rock it has been found best to put the air pressure into the hole, loosen the top rock in this way, and then remove it. If concrete has been placed over the rock, or if a seam is well down but large and open, continue grouting with a thick sandy grout until the seam is surely well filled with grout and then leave the grouting for a day or so to give the grout a chance to set in the seam. Repeat this operation until the hole is tightened. Secondary holes then are quite essential because the large seam may have so vented the pressure originally that other smaller seams were not filled with the grout.

Suggested Method of Grouting and Proving the Rock Foundation of a Masonry Dam.

It seems to the writer that the following would be the most satisfactory arrangement of holes and method of procedure for the tightening and proving of the rock foundation of a masonry dam after all loose surface rock had been removed.

1. Drill two rows of primary holes 7 ft. apart with holes 15 ft. apart in each row and staggered, the upstream one of these rows to be located just under the upstream face of the dam. Test and grout these holes.

2. Drill, test, and grout secondary holes as needed between these.

3. Drill, test, and grout tertiary and even quarternary holes if needed to finally prove the grouting.

4. After this grouting is finished, section by section if the work is so carried on, drill vent holes about 15 ft. back of the upstream

face of the dam, spaced 10 ft. apart, of such depth as the testing of the grout holes shows to be necessary, and carried by pipe up into the inspection gallery of the dam to be observed, tested, and grouted or treated as needs be after the water is ponded against the dam.

5. If there is to be considerable head of water on the rock foundation due to the water standing on the downstream side of the dam, in so far as is reasonably possible by the removal of loose rock, by drilling and grouting of holes, or by placing of vent pipes at outflows to be grouted later, make tight the rest of the rock bottom below the elevation to which water will stand on the downstream side.

6. Above the elevation to which water will stand on the downstream side, unless springs under pressure are encountered, make no attempt to tighten the rock bottom downstream from the upstream grouted section.

Discussion.

Mr. Frank L. Fuller. I should like to ask if this grout was put down through the pipes, and were the pipes raised as the grouting continued?

Mr. Garratt. Yes, when it was necessary. Holes were drilled into the rock 25 ft., and into the tops of those holes a pipe extending below the surface about a foot was cemented, so that the rubber hose from the mixer could be fastened to the pipe and the grout forced into the hole.

Mr. Harold K. Barrows. Was that work done by the contractor at the various dams or in some other way?

Mr. Garratt. The labor was furnished by the contractor, but we always had a representative there. I myself did a good deal of the directing.

Mr. Barrows. I want to ask further how it was paid for, — whether as a matter of time or how?

Mr. Garratt. No. It was paid for by items. There were various items of connections for grouting, cubic yards of grout forced into the hole, — of the pipe used in the hole. The cement was paid for as a separate item.

CARE AND OPERATION OF MECHANICAL RAPID SAND FILTRATION PLANT.

BY JOHN W. GAITENBY, SUPERINTENDENT FILTRATION PLANT, EVANSTON, ILL.

[*Read September 12, 1917.*]

Mr. President and Members of the New England Water Works Association, — At the request of your President, Mr. Saville, I have prepared a short, informal paper on the care and operation of a rapid sand filtration plant.

The plant of which I have the honor of being superintendent is located at Evanston, Ill.. and is a municipally owned plant of 12 million gallons' daily capacity per twenty-four hours. This plant was installed for the city by the Norwood Engineering Company of Florence, Mass., from plans and specifications prepared by George W. Fuller, of New York, and Langdon Pearse, of Chicago. The contract was let in 1913 and completed in 1914.

The plant consists of six filter beds, each having a filtering area of 738 sq. ft., with a filtering capacity of 2 million gallons each per twenty-four hours, or at the rate of 125 million gallons per acre per day. The source of supply is from Lake Michigan, through an intake pipe extending about $1\frac{1}{16}$ miles out into the lake, but still within the range of drift for the sewage of Evanston and Wilmette, a town to the north, the greater part of which is discharged into the lake.

During the five years previous to the installation of the filter plant, the average death-rate in Evanston per 100 000 was 26.6. Since the installation of the filter plant, the death-rate has been greatly reduced, and since 1916 there is no record of any deaths from typhoid fever, although the raw lake water has shown indications of B. coli in practically all samples taken before treatment.

Care and Operation.

To operate a filter plant efficiently, a certain portion of the work should follow a definite schedule. The operations which can generally be so arranged are the regularity of making tests, the proper preparation of the coagulant solutions, inspection of the plant, especially the condition of the filters, and the washing of same.

The first and most important matter to be considered is the necessity of having good, reliable help at all times, who can keep correct records of all operations and results, and who are able to figure or compute the different amount of chemical fed to each million gallon or part thereof that is being pumped to the plant at all times, for in some plants the pumpage is uniform throughout the twenty-four hours, while with others, as in our case, it varies from 3 to 17 million gallon rate throughout the twenty-four hours. At our plant, the amount of water pumped to the filter is registered by means of a Venturi meter, and readings are taken each hour; and whenever the engineer at the pumping station wishes to change the rate of pumpage he notifies the operator at the plant, and he immediately changes the chemical feed and filter rate controllers accordingly. Lake Michigan water varies so little that we are able to run practically the same amount of coagulant at all times.

Care of Sand in the Beds.

Each bed is inspected during the washing, to see that the wash is uniform, and once a week the water is drawn off of the filters entirely and the sand examined. If patches of dirty sand, or mud balls, are found, the beds are raked up and down with a heavy double-tooth rake made for that purpose, allowing a small amount of wash water to be applied to the filters during this raking process. After this raking process, the wash water is turned on for about three times its ordinary washing period, so as to carry all dirt over into the wash gutters. The filter is then drained again for inspection and is sterilized by sprinkling with a strong solution of chloride of lime. Both the walls and the sand are allowed to stand in this condition a couple of hours, when it is washed again to remove the chloride of lime solution.

Rate Controllers.

The rate controllers are examined at frequent intervals, to see that they check up with the master controller, and each bed is measured to see that they are uniform and check with the rate controller.

All of these different operations are registered on specially prepared sheets or charts for that purpose, which are kept for future reference and which are transferred to the monthly operating sheets.

Loss of Head Gages.

The loss of head gages are read every hour and recorded. When the loss of head reaches 11 ft., the filters are washed in the usual manner by closing the influent valve and allowing the water to filter or lower in the beds to a level with the tops of the sewer gutters. Then the effluent valve is shut, the sewer valve opened, and the wash-water valve is opened slowly and gradually until the required amount of wash water is being obtained. The exact time required for washing the filters is recorded; also the exact amount of wash water is recorded. The influent valve is then opened partially, and the filter bed is allowed to fill up to the same level as the other filters and the bed allowed to stand for a few minutes before being put on to the filtering process again.

High-Velocity Wash.

We use at our plant what is known as the "high-velocity wash." In other words, we use 15 gal. of filtered water per square foot per minute for washing the filters, and while this high rate of wash water keeps the sand in good condition, I do not think that it is any better than the normal rate of washing combined with air. I have had considerable experience, both with the normal rate of washing with the combined air wash and with the high rate of wash, and I have found that the sand bed is agitated much more thoroughly and kept in a very much cleaner condition with the combined water-and-air wash than with the high-velocity wash, besides saving a very large amount of filtered water in this washing process.

Tests.

Each day the water in the settling basins and on the filter is inspected to ascertain the condition of the floc or aluminum hydrate, and the turbidity is taken of the raw and settled water, also the temperature. We also take samples of the raw, settled, filtered, and sterilized water for bacteriological analysis and plate samples of each on agar and gelatine plates, and incubate same for forty-eight hours at 20 degrees C. We also plate these samples on litmus agar plates for twenty-four hours at 37.5 degrees C., for acid colonies and pathogenic type; also tube samples of each water in lactose bouillon at 37.5 degrees C. for twenty-four hours for gas formation. The results of these tests are recorded on index cards printed for that purpose and transferred to the monthly report sheets.

The entire plant is kept clean by sweeping and mopping, and the woodwork and iron work are painted so as to keep same in a clean and sanitary condition at all times. The plant is opened for inspection to the public at all times.

The bacterial efficiency of the plant is very high, averaging, for the year 1916, 99.86 per cent.

The settling basins are cleaned by draining through valves located in the bottom of same for that purpose, and are washed out with a fire hose every six weeks.

Cost to Filter Water.

During the year 1915 we filtered 2 325 400 000 gal., or an average of 6 371 000 gal. per day. Of this amount we used 85 589 000 to wash the filters, or 3.68 per cent., at a total cost of $9 203.00, or $3.96 per million.

Average amount of alum used..... .72 gr. per gal.
Average amount of hypo used.....3.5 lb. per million

This total cost per million gallons includes salaries, chemicals, supplies, light and power, etc., divided as follows:

Chemicals.....30 per cent.
Salaries.....55 per cent.
Light, power, supplies.....15 per cent.

Hypo.....3c. per lb.
Alum.....1c. per lb.

During 1916 we filtered 2 495 040 000 gal., or an average of 6 808 000 gal. per day, at a total cost of $9 587.92, or $3.80 per million, divided as follows:

Chemicals..... 35 per cent.
Salaries.....53 per cent.
Light, power, supplies.....12 per cent.

Of this amount of water, 72 865 000 gal., or 2.92 per cent., was used to wash the filters.

Hypo, 7c. per lb. 4 lb. per million gallons.
Alum, 1.28c. per lb. Average amount used, .67 gr
Total number of men employed, 5.

STATE WATER SURVEY.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ILLINOIS.
URBANA, ILL., May 25, 1917.

LABORATORY NO. 37147.

Report of the Sanitary Analysis of Water.

Sent by John Gaitenby.
Town: Evanston.
Source of water: Raw water.

(Amounts are stated in parts per million.)

Turbidity, 20. Color, 5. Odor, 0.

Residue on evaporation....	180.	Bacteria per cc.:	
Chlorine in chlorides.....	5.	Gelatine.....	60
Oxygen consumed.....	3.6	Agar.....	80
Ammonia nitrogen.....	.022	Gas Formers:	
Albuminoid nitrogen.....	.102	10 ccm.....	1+
Nitrite nitrogen.....	.000	1.0 ccm.....	2−
Nitrate nitrogen.....	.64	0.1 ccm.....	1+1−
Alkalinity, phenolphthalein			
Alkalinity, methyl orange..	122.	Indol.....	

The analysis indicates that the raw water had received some contamination. It should not be used for drinking purposes unless properly treated.

ANB/R
See enclosed circular.

EDWARD BARTOW,
Director State Water Survey.
A. N. BENNETT,
Chemist.

37147

STATE WATER SURVEY.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ILLINOIS.

URBANA, ILL., May 25, 1917.

LABORATORY NO. 37148.

Report of the Sanitary Analysis of Water.

Sent by John Gaitenby.
Town: Evanston.
Source of water: Filtered water.

(Amounts are stated in parts per million.)

Turbidity, 0. Color, 0. Odor, 0.

Residue on evaporation	150.	Bacteria per cc.:	
Chlorine in chlorides	5.	Gelatine	1
Oxygen consumed	3.3	Agar	12
Amomnia nitrogen	.010	Gas Formers:	
Albuminoid nitrogen	.056	10 ccm	1 –
Nitrite nitrogen	.000	1.0 ccm	2 –
Nitrate nitrogen	.24	0.1 ccm	2 –
Alkalinity, phenolphthalein			
Alkalinity, methyl orange	118.	Indol	

The analysis shows that the water had been properly treated and that it was in excellent sanitary condition and suitable for drinking purposes at the time of sampling.

ANB/R
See enclosed circular.

EDWARD BARTOW,
Director State Water Survey.
A. N. BENNETT,
Chemist.

37148

NOTE. There are on file at the Association rooms, Tremont Temple, relating to Evanston, Ill., filtration plant, and accompanying above paper, the following:

Paper — "The Rapid Filter Plant at Evanston, Ill.," by Langdon Pearse; read before M. W. S. E., 1913.

Report, by Consulting Engineers Walter W. Jackson and Langdon Pearse, to City of Evanston, Ill.

Blank form for laboratory report on samples.

Blank form for chemical and general records.

Blank form for daily filter report.

Tables — Monthly summary of operation and results for June, July, and August, 1917.

Discussion.

Mr. Harold C. Stevens. I should like to ask Mr. Gaitenby's opinion as to how the air acts in producing the good effect. Some people seem to think the whole bed is affected, the sand tumbled about, loosened. It seems to me, as the air leaves the strainers, it finds certain passages and continues to flow along those passages, disturbing the sand on the surface.

Mr. Gaitenby. I don't know; I don't think they do. They might possibly do such a thing on a plant where an air system had been in for some time and some of the air openings plugged or spaced too far apart. But if they use slots in their air tubes the bed will look as though the water was boiling, — it is rolling all over. And in a plant where the air is sufficient, and the slots in the tubes, or any other device, are equally spaced, and all of the same size, none plugged, you ought to get just as much air one place as another.

Mr. Stevens. In some places I know you can, for we have places where the air is coming up. There are little craters all over the bed, — springs.

Mr. Gaitenby. You will note that there is sediment of some kind that might get into these tubes and plug up some of the slots, and that would of course force the air out through a very few. That might happen. I have known instances — not necessarily on municipal plants, but on industrial plants — where it would throw the gravel up, there was so much air in some sections of bed and in other sections of the bed there was none, the pipes were plugged. The main air pipe was filled with sand or gravel.

Mr. Stevens. I remember one filter where it showed uniformly over the whole bed. The strainers were spaced about six inches, and the air reflected downward.

Mr. Gaitenby. I believe all filter plants that use air systems do not work the same. I think a good thing to do would be to set the safety valve on your air compressor, whatever you use, to a certain pressure for that plant. It might be all right on this plant and no good on the next plant. You have to use your own judgment. Where it might take five pounds pressure and a certain number of cubic feet of air to wash one bed, at another

bed it might not take nearly as much. Air, to be effective in washing filters in connection with wash water, should be a separate system so as to use both wash water and air through separate systems, and the openings for air should be very small holes or slots spaced not more than three inches apart all over the area of the filter bed. This air system works best if placed above the gravel layers in the beds. In this position it does not disturb or misplace the gravel.

SOME ASPECTS OF STREAM POLLUTION IN CONNECTICUT.

BY J. FREDERICK JACKSON, DIRECTOR BUREAU OF SANITARY ENGINEERING OF THE DEPARTMENT OF HEALTH, STATE OF CONNECTICUT.

[*Read September 13, 1917.*]

The question of stream pollution in Connecticut began to attract public attention about the middle of the nineteenth century, coincident with the construction of sewerage systems by towns and municipalities. Undoubtedly there was more or less contamination by mill towns prior to that time, but its extent and character was not such as to attract general notice. The agitation was caused, as examination of the court records of those days will show, by the attempt of individual riparian owners on non-navigable streams to assert their rights to have the water of a stream covering their lands flow in its accustomed manner.

With the growth of cities and increase in number and size of industrial plants, the condition of the streams — both navigable and non-navigable — grew rapidly worse, and we find the people of the state as a whole seeking to maintain their rights against powerful municipalities and large industrial corporations. This movement has been a slow one because it is axiomatic that the people as a whole move less easily and quickly than the individual. But it has been a very persistent movement, and its force was evident when the General Assembly in 1913 instructed the state board of health to investigate the pollution of the waters of the state, both tidal and inland, and recommend means for terminating it. This the state board did, and their report to the General Assembly of 1915 was largely instrumental in forcing the passage of the present statutes relating to sewage disposal and the protection of water and ice supplies. In the meantime, municipalities and privately owned water companies had abandoned the use of the larger rivers as sources of supply, and sought others

remote from centers of population and less liable to contamination. It may be of interest to reflect that we might to-day be drinking water of the Connecticut and Housatonic properly filtered if the application of Wanklyn and Franklin's discovery of method of determining organic matter to the filters at London had not been so disappointing in the small amount of organic matter removed, causing that city to seek unpolluted sources, or if the significance of the germ theory in its relation to water purification had been fully understood.

To me the thought of the economic waste of millions of gallons rushing by the very doors of some of our larger cities — water generally satisfactory in most of its physical characteristics, and with modern methods of filtration entirely so, from the standpoint of health — is to some degree depressing. No water-works' official, no matter how ideal his source of supply may be, feels absolutely safe from accidental contamination, and all the trouble and expense of bringing water from distant sources will in most cases not avoid the necessity of finally filtering the water.

Engineers are prone to consider that half the solution of any problem lies in separating it into its component parts. In the study of any river of considerable magnitude, the conditions affecting its pollution are so varied and complex that their segregation is very difficult. How much greater must this be when we consider all the rivers and inland waters of a state like Connecticut. The watersheds of the Connecticut, Housatonic, and Thames alone comprise about 71 per cent. of the total area, and the lakes, swamp, and salt marsh total about 145 square miles. The estimated population is 1 238 723, the density per square mile being 231.3; only three states in the Union exceed this. About 89 per cent. dwells in cities and towns and 23 per cent. is employed in manufacturing. In value of manufactured products she ranked twelfth in 1909, producing $490 272 000 worth, of which the materials cost $257 259 000, leaving the net wealth created $233 013 000.

Studies of pollution of a stream may be under any of the following forms: source of water supply, disposal of storm water, shipping, water used for industrial processes, fishing, boating, bathing, camping, disposal of refuse.

There are 105 water companies located in 99 towns out of 168 towns of the state. Twenty-two of these are municipal and 83 private. In addition, there are 6 institutional supplies. None of the towns take their supply from the larger rivers. The larger companies are, and have been for some years, protecting their source of supply by acquiring land, by patrol, and by laboratory control. Eleven have some method of filtration and 8 others disinfect.

Most of the towns dispose of storm water into the nearest water-course. Thirty-eight towns have sewerage systems and 17 treat their sewage. The different methods of treatment are 7 sand filtration, 2 sand and broad irrigation, 3 septic tanks, 1 septic tank with contact beds, 2 digestion chambers followed by sand filtration, 2 Imhoff tanks with disinfection.

Shipping to any considerable extent is restricted to the Thames, Connecticut, Quinnipiac, and Housatonic.

All manufacturers located on streams use them unrestrictedly in processes of manufacturing, subject only to riparian rights of owners above or below. Very often the entire flow of a river is diverted to pass through the factory, and is discharged below in very bad condition.

Fishing as an industry has practically disappeared. The value of the oyster industry in 1905 was $2 809 839; in 1910 it had decreased to $1 885 494; the number of shad taken in Connecticut River in 1903 was 176 085; in 1913, it was 52 053; and, except for the efforts of Fish and Game Commissions, there would be but little fishing left for the sportsman.

Camping, bathing, and boating, with the growth in population, shorter hours of labor, and general observance of Saturday half-holiday, is increasing every year, and in particular is this so along the shore front. The bathing beach which is not polluted is an exception.

Disposal of refuse only affects the streams when public dumps abut the shore front.

The problem is to study, classify, and correlate the different uses of our tidal and inland waters so as to cause a minimum of inconvenience to our growing municipalities and industries and still safeguard and preserve the rights of the general public.

The first and most important of these is preservation of public health. The wealth of a nation lies in the health of its citizens. Little pride is to be taken in populous cities and thriving factories if peopled and operated by a sickly and anemic race. The phrase "public health" is purchasable, has become a household phrase, and where it is concerned all other uses of a stream menacing it must be eliminated.

This result being assured, the further study should consider each stream in its relation to the public welfare, giving due weight to economic values of the interests affected. Absolute prohibition of their use for the disposal of wastes is rarely wise. Restricted use to conform to ever-increasing standards of public decency is both possible and desirable. This result can only be obtained through coöperation. No longer is there such a marked tendency on the part of municipalities to put off the installation of sewage treatment works awaiting the perfection of some undeveloped method to furnish a universal solution of waste disposal. No longer is the attitude of forward-looking men, engaged in manufacturing, strongly antagonistic to all legislation regulating the use of streams in disposal of industrial wastes. They have realized that something has to be done to preserve in our streams even a moderate degree of purity, and are giving to the question the same intensive study which has brought them success in their own particular field. While the problem is most complicated, certain fundamentals have been laid down in at least two instances which we may safely take for our guidance. In their report to the Great Lakes International Pure Water Association and the National Association for Preventing Pollution of Rivers and Waterways, in 1911, the committee formulated these general principles.

Streams from which Water Supplies are Taken without Purification. Such streams should not receive any fecal matter, sewage, sewage effluent, or wastes that will render the water a menace to health or otherwise impair its natural quality.

Streams from which Water Supplies are Purified. Such streams should not receive fecal matter, sewage, sewage effluent, or waste matters in such quantities that the contamination of the water at any water-works intake would put an unreasonable burden

upon the purification works or in quantities sufficient to produce the conditions referred to in the next paragraph.

Streams Not Used for Water Supply. Such streams may receive sewage wherever and in such quantities that its entrance will not sensibly offend decency in the reasonable public use of the stream, or cause interference with navigation or with valuable fish industries or the ice industry. Where this cannot be done, the sewage or wastes should receive such treatment before discharge as to bring the effluent within this rule, due regard being given to the relative cost of the processes required and the benefits to be derived.

Large Lakes from which Water Supplies are Not Filtered. Such lakes should not receive fecal matter, sewage, sewage effluents, or other waste matters in such amounts or at such places that the water reaching the intake would be contaminated to the extent that an unreasonable load would be placed upon the filter, or in quantities sufficient to produce the conditions referred to in the next paragraph.

Lakes Not Used for Water Supply, Harbors and Estuaries. Such bodies of water may receive sewage if discharged in such a manner as to be quickly and thoroughly diluted so that its entrance will not sensibly offend decency in the reasonable use of the water, or interfere with navigation. Where this cannot be done, sewage should receive such treatment before discharge as to bring the effluent within this rule, due regard being given to the relative cost of the processes required and the benefits to be derived.

And again, in the report of the Committee on Sanitary Control of Waterways, to the Sanitary Engineering Section of the American Public Health Association, in 1916, the committee, after several years of careful study, recommend the adoption of — (1) There shall be no objectionable deposits at any point in a waterway as a result of sewage or other wastes discharged therein; (2) there shall be no local nuisance created at or in the vicinity of any sewage or industrial wastes outfall, arising from excessive turbidity or the production of odors; (3) there shall be no general nuisance created in a waterway due to excessive turbidity or to odors, as a result of sewage or other wastes discharged therein; (4) there shall be no interference with or undue burden upon

mechanical operation or bacterial efficiency of water purification plants procuring their raw water from a waterway; (5) there shall be no active (potentially dangerous) bacterial contamination or gross pollution of properly located and authorized shellfish beds; (6) there shall be no active (potentially dangerous) bacterial contamination or gross pollution of properly located and authorized bathing beaches and other bathing places.

Both of these reports are admirable and the work of men foremost in sanitary knowledge in the country. It is interesting to observe the change in five years as evidenced in these two reports, and to note that it is not in the line of less restrictions.

Public sentiment is demanding, and will continue to demand, greater rather than less restrictive regulation of pollution of our streams; and while we may never expect to see the rivers of Connecticut restored to their pristine condition, we may confidently hope that the more beautiful stretches will again be used for boating and fishing, that flocks and herds will pasture once more on many barren hillsides, and her harbors and estuaries be free from gross pollution so destructive of fish life and restrictive of bathing, — all accomplished through the harmonious efforts of state, municipal, and industrial interests, working hand in hand.

SOME OPERATING PROBLEMS OF A SMALL WATER DEPARTMENT.

BY HOMER R. TURNER, SUPERINTENDENT AND ENGINEER, THE WINDSOR FIRE DISTRICT.

[*Read September 12, 1917.*]

The town of Windsor is situated on the west side of the Connecticut River, six miles north of Hartford. There is a small amount of manufacturing, the balance of the town being devoted to farming and a suburban residential section for the city of Hartford. The water supply is obtained from Mill Brook, two and one-quarter miles west of the populated district known as Windsor Center, and is pumped from an impounding reservoir on that stream to the standpipe situated on Cook Hill, one mile west of the district. From there it flows by gravity through two independant supply mains to the distribution system.

The town of Windsor, after negotiations in 1910, had refused to purchase the plant of the Windsor Water Company, a private corporation. In 1915, the thickly populated part of the town obtained a charter from the legislature incorporating the Windsor Fire District, with authority to purchase the Windsor Water Company. As a result, the Windsor Water Company came under municipal ownership and plans were immediately made for improving and strengthening the system. Contracts were awarded for new pumping equipment, a steel standpipe, and extensions and strengthening of the distribution systems, including the installation of fire hydrants throughout the district.

Water Purification.

The impounding reservoir, known as Barber's Pond, has a storage capacity of 15½ million gallons, and has a watershed of approximately two square miles. A large part of this drainage area is devoted to tobacco raising, there being several large plantations on the watershed.

In January, 1917, during freshet conditions, positive tests for colon bacillus were first obtained. Recurrence of this colon test proved the necessity of treatment of the water before pumping into the distribution system. In July, 1917, the Board of Commissioners of the district authorized the installation of a liquid chlorine disinfection plant. Under the direction of Mr. James A. Newlands, chemist for the water department, the writer immediately installed a solution feed, manual controlled, chlorinator, manufactured by the Wallace & Tiernan Company. This chlorinator is connected to the suction main of the pumps, and is housed in a separate building about 30 ft. from the pumping station. The water is being treated with chlorine at the rate of six-tenths parts per million. The comparative tests of raw and treated water have shown a reduction in bacteria of 85 per cent. and a reduction in colon bacillus of 100 per cent.

During July of this year disagreeable odors were noticed in the water, and an investigation showed that large masses of spirogyra had become caught on fixed growths in the shallower portion of the reservoir bottom. On decomposing, this had produced the odors noticed in the water. The condition became rapidly worse, and in less than twenty-four hours the whole reservoir was impregnated with this odor. The writer decided immediately to drain the water from the reservoir and pump from the brook direct. By following this course it was possible to leave the bed of the reservoir exposed to air and sunlight, thus enabling oxidation of the decomposing matter to become more complete. Furthermore, the water obtained from the brook was comparatively fresh and free from the odor of the decomposing matter. The chance of contamination incidental to taking water from the flowing stream was eliminated by the liquid chlorine treatment. After the reservoir had been drained for ten days, the offensive matter was sufficiently oxidized so the sluice gates could be closed.

Pumping Equipment.

The Water Company's original equipment consisted of two No. 80 Rife rams and an 8 in. by 12 in. Gould's triplex single-acting pump having a capacity of 300 gal. per minute. This pump

was connected direct to a 10-h.p. gasoline engine. The gasoline engine was subject to internal disorders at unexpected times, and as the storage capacity of the concrete reservoir was less than one day's consumption, it was imperative that additional pumping equipment be installed to reinforce the fire hydrants then being placed throughout the district.

The rams were discarded, and the space utilized for a 10 in. by 12 in. Smith-Vaile triplex power pump, having a rated capacity of 1 050 gal. per minute. This pump is operated through chain drive by a 100 h.p. Westinghouse slip-ring motor. As the unit was to be operated but three to four hours per day, it was thought advisable to provide for automatic operation in case of emergency or extreme low pressure. For this reason there was installed a Westinghouse alternating current magnet switch starter, controlled by a pressure gage switch. This switch is satisfactory for starting the pump on low pressure, but experience has shown that it will not operate within close limits for stopping the pump when the standpipe is filled. A positive action float switch which can be installed at the top of the standpipe will prove the only satisfactory method of automatically controlling the apparatus.

Compression grease cups and ring oiled bearings on pump and motor insure proper lubrication in case the machinery is started with no attendant present. At first the chain drive gave us some trouble in the matter of lubrication, on account of high-speed operation which caused oil to fly off the surface of the chain without working into the links. This difficulty was overcome by installing a perforated one-half inch pipe between the top and the bottom of the chain. An oil cup controlled by a valve feeds oil to the inside of the chain, where centrifugal force works the oil out through the links and keeps the chain properly lubricated.

In order to provide additional storage and higher pressure, a steel standpipe 105 ft. high by 30 ft. diameter was constructed near the old storage tank. This gave an increased capacity of 554 000 gal. and a maximum pressure down town of 87 lb. per sq. in. The working pressure runs from 75 to 80 lb. during the day. There is an available water supply for fire hose without pumping engines of 2 800 gal. per minute in the business district.

Leadite Joints.

In drawing up the proposals for the water mains contract, alternative prices were asked, first on laying cast-iron pipes with lead joints, second on laying cast-iron pipes with leadite joints. The contractor to whom the work was awarded, offered to do the work with leadite joints for 10c. per foot cheaper than with the lead joints. After favorable replies were received from several users of leadite, we determined to use the material.

Leadite was used on about 28 000 ft. of 10-in. water main. The material comes in the form of a black powder put up in 100-lb. bags. We used an ordinary portable furnace, burning coke, controlling the temperature by dampening the fire with soil when necessary. One attendant is kept on this furnace continually, as the material requires constant stirring and proper control of the temperature to prevent burning. The leadite is melted until it is of the consistency of medium oil, and the appearance of the surface of the liquid is smooth and free from bubbles. At this stage it has a mirror-like surface and is ready to pour. The temperature at this time is very slightly above the melting point, and a higher temperature will cause bubbles to appear. Any increase in temperature will cause the material to thicken until it becomes stringy. If this occurs, the pot should be removed from the fire and cooled until the temperature is reduced so that the material is of the proper consistency. Dry jute should be used in the joints. The presence of oil or grease from tarred jute prevents a good bond between the leadite and the cast-iron pipe. The material is poured similar to lead, it being necessary, however, to build the gate at least 3 in. high above the top of the bell. This is required as the material is too light to flow back into the joint at the top of the bell of the pipe without a slight head to force it back. Joints made up with an ordinary gate, such as is used for lead, proved to be imperfect, as the material did not properly fill the joint at the top. The leadite in the gate can be broken from the joint when cold and remelted after being properly cleaned.

Experience proved that we have obtained better results with the joints if the pouring was kept back at least four lengths of pipe from the laying gang. The shock of driving home a new

length of pipe tends to break a freshly made joint. One serious disadvantage in the use of the material is its tendency to crack, being brittle on new work. One 6-in. pipe crossing under a railroad track, which was laid in 1914, has broken down at the joints, and it has been necessary to cut out the leadite and use lead in this location. Another disadvantage in repairing a defective leadite joint is the necessity of shutting the water off the main. It has been found impossible to calk or patch a leadite joint with lead wool or other material. Best results are obtained by entirely removing the leadite from the joint and either repouring the joint with leadite or lead. On the other hand, the ease with which plugs can be cut out or joints cut away in order to remove several lengths of pipe has proven of distinct advantage.

Tests of Leadite Joints.

As the standpipe was not completed when the pipe lines were laid, we were forced to omit exact tests of joints after pouring, but each joint was inspected when a section was filled with water before back filling was done. Final tests were made this year.

The only method available in making these tests was to shut off each service connection at the curb cock and to shut off all gates on adjacent lines. Table 1 gives data showing the number of services and length of service connection involved in the tests, and also the number of gates which it was necessary to close. No doubt some of the water measured as leakage was lost through leaky services or gates, but the results in Table 3 have been figured on the assumption that the total loss of water was through the leadite joints only. The standpipe was pumped full of water, to give the maximum available pressure on the lines to be tested. Table 2 shows the relative pressures on different sections of the line, 35 per cent. of the length ranging from 45 to 70 lb. and 65 per cent. ranging from 70 to 98 lb. per sq. in. The standpipe was shut off from the distribution system and the water supplied for leakage on the tested lines was by-passed through a 1-in. meter. Gage readings of the pressure on the lines were taken at two points during the tests. The duration of the test was four hours; the actual quantity of water registered through the meter was 39.4 cu. ft., or 1 773 gal. per twenty-four hours. Correction for under-

registration of the meter gave a total loss of water from leakage of 1 861 gal. of water per twenty-four hours, or 0.360 gal. per twenty-four hours per linear foot of joint.

Maintenance of System.

The water company, before its purchase by the district, had found it less expensive to have new service connections installed by plumbers than to maintain a gang on this work. Since 1915 the plant has expanded rapidly, and the old methods proved too expensive both in time and money. A maintenance gang was organized, necessary tools and a Ford one-half ton truck were purchased, so that all new work, service connections, and repairs are now handled at a saving of 33 per cent. in cost and in minimum time allowance. The truck can haul a trench pump, tools, and six men for emergency repairs, and get to the job in the shortest possible time.

Waste Prevention.

The water is now sold by flat rate to private consumers, the charges being based on the number of fixtures in use. Business and manufacturing establishments are on meter system. On account of the flat rate system in use there is of course more or less leakage from defective plumbing. This is reduced as far as possible by regular house-to-house inspections, and has resulted in cutting down the consumption from 75.4 gal. per day per person during 1915 and 1916, to 66.5 gal. per day per person during 1916 and 1917.

Municipal ownership of the water-supply system has proven a success in Windsor. The Windsor Fire District is assured of effective fire protection service at cost, and, which is more important, it is assured of a constant supply of water for domestic uses free from disease-carrying bacteria. The department paid the interest on its bond issue during the first year without additional taxation, and during this year has turned over an operating profit of about $2 500.

TABLE 1.

DATA REGARDING MAINS.

Location.	Length of Main. 10 In. Ft.	8 In. Ft.	Total No. Joints. 10 In.	8 In.	6 In.	Services. No.	Length. Ft.	Gates. No.	Size. In.
Sage Park Road....	7 674	128	656	16	7	4	70	3	8
Windsor Avenue....	14 640		1 271		48	58	1 633	2	10
								4	6
Total.....	22 314	128	1 927	16	55	62	1 703		

TABLE 2.

RANGE OF PRESSURE ON MAINS.

Location.	Length. Ft.	Pressure. Lb. per Sq. In.	Per Cent. of Length.
Sage Park Road....	2 228	45	10
Sage Park Road....	5 574	64	25
Windsor Avenue....	7 600	73	34
Windsor Avenue....	4 400	94	19
Windsor Avenue....	2 640	98	12
Total.....	22 442		

TABLE 3.

LEAKAGE — SAGE PARK ROAD AND WINDSOR AVENUE.

Date.	Size Main. In.	Lin. Ft. Joint.		Leakage in Gal. per 24 Hr. Total	Per Lin. Ft. of Joint.
August 24, 1917....	10	10 in. —	5 048		
		8 in. —	33	1 861	0.360
		6 in. —	86		
			5 167		

DISCUSSION.

MR. FRANK L. FULLER. I should like to inquire, Mr. President, how you remove a pipe that has been laid with leadite.

MR. TURNER. Our method of removing a length of pipe is to take an ordinary calking iron and to sharpen it to a point, so that instead of having a flat edge it is drawn out to a long V, and then we cut out the leadite with this tool. The leadite is very brittle and comes out in the form of a powder when the joint is cut. So that we can cut all the material out of the joint, and by cutting out three or four joints we are able to remove a section of the pipe.

MR. FULLER. Did I understand you to say the price was ten cents a foot alone, for laying it with leadite?

MR. TURNER. Yes. I might add that the contractor who did

the work was very faithful in the performance of his duty, otherwise I doubt very much if we would have obtained as good results on our test as we did. I think that the work of putting in leadite joints is something that requires very faithful performance. It is not a work that can be done slipshod.

Mr. Frank E. Merrill. I should like to ask the speaker if he ever tried to burn out leadite joints. This year I have had my first experience with using material of this kind in laying a line of 12-in. pipe, — it was hydrotite which we used, which is similar to leadite, — and we attempted to remove one joint by the use of the chisel, and found it very difficult work to get it out. We built a fire around it and melted it out and got it out very nicely. I should also like to ask if he can give me any idea of the cost of trench work, back-filling, laying, furnishing the joint material and running the joints of a 12-in. pipe with leadite, the pipe to be in a trench five feet deep.

Mr. Turner. In regard to the first question, we have never attempted to burn out the leadite joints, because we found it was very easy to chip it out; in fact, it is a great deal easier to chip out the joint that is made of leadite than it is to burn out a lead joint. In regard to the second question, I am unable to give any figures that would be of value to you as to the cost of laying the 12-in. main. This leadite, I understand, on the last quotation, was quoted at ten cents a pound, which at the present time is somewhat cheaper than lead. It weighs only about one quarter as much as lead, so that it is supposed to go four times as far, although I doubt very much if it does. I think perhaps three times would be a good allowance to make for it.

Mr. P. J. Conlon. Do you think it would be cheaper to dig up four lengths of pipe than to use a sleeve and cut out one length of pipe, whether leadite or lead?

Mr. Turner. I don't think it would be if we had to dig the main up. It would be very much cheaper to cut out one length of pipe and put in a sleeve than to dig up four lengths. But if you wanted to take out a long line of pipe and salvage the pipe, it is very much easier to cut out the old leadite joints than it is to burn out lead joints. I know that we have had the experience of cutting out plugs on T's which have been inserted in lines for future hydrants, where we find that we can cut out a T in about

ten minutes' time, whereas if we had to burn out a lead joint or cut it out with a chisel it would take very much longer.

MR. FRANK L. FULLER. I should like to inquire, Mr. President, in regard to the tightness of these joints, — whether you had any trouble from leakage.

MR. TURNER. When we first filled our sections of pipe, all of the joints seeped considerably, and some had quite pronounced leaks on them, but after the pressure had been on about twelve hours the leaks all stopped, and after forty-eight hours the seepage all stopped. The joints seem to tighten up after the water is turned on to the line. I notice from our pumping record there was considerable leakage on the new lines for about two weeks after they were laid, and then that was gradually reduced so that at the present time I know that the leakage on the leadite joints is very small, as the result of our tests shows. Where the leakage on twenty thousand odd feet of 10-in. main was at the rate of only $\frac{3.6}{100}$ of a gallon for twenty-four hours per linear foot of joints, that is, I think, a very good test.

MR. FULLER. How long has this pipe been laid?

MR. TURNER. This pipe was started in the fall of 1915 and completed in the spring of 1916. The test of the joints was made about three or four weeks ago.

MR. GEORGE A. STACY. I should like to inquire if you had any trouble with wet joints.

MR. TURNER. We seemed to have a little trouble with wet joints at first. That is, they leaked more than the dry joints did. But the wet joints gradually closed up after the line had been in service for some time. I think that the worst trouble we have had with the leadite joints has been where there was oil or grease which has come in contact with the pipe. For some reason or other, the leadite will not bond on the cast iron if there is grease or oil present. The principal thing in the laying of cast-iron pipe, I think, is to see that the jute is properly driven into the bell. That is the foundation of the joint. And in order to do that you must have the joint big enough to work around it. I don't think we save anything on the bell holes. We excavate our bell holes just exactly as much for leadite as for lead joints.

MR. FULLER. How deep were the joints?

MR. TURNER. Two and one-half inches deep for leadite.

PROCEEDINGS.

June Outing.

Meeting of the New England Water Works Association was held at Norumbega Park, Newton, Mass., Wednesday, June 13, 1917, at three o'clock P.M., Vice-President Carleton E. Davis presiding. The following members and guests were present:

Honorary Members.

Frank E. Hall. George A. Stacy. Robert J. Thomas. — 3.

Members.

D. L. Agnew.
S. A. Agnew.
L. M. Bancroft.
C. H. Bartlett.
C. A. Bingham.
Alvin Bugbee.
H. B. Burley.
R. D. Chase.
J. E. Conley.
C. E. Davis.
E. D. Eldredge.
R. H. Ellis.
James Fitzgerald.
R. J. Flinn.
H. F. Frost.
F. L. Fuller.
F. C. Gamwell.
F. J. Gifford.
T. C. Gleason.
D. A. Heffernan.
W. F. Howland.
W. F. Hunt.
W. S. Johnson.
Willard Kent.
S. E. Killam.
G. A. King.
C. F. Knowlton.
W. J. Lumbert.
W. E. Maybury.
Hugh McLean.
John Mayo.
H. A. Miller.
W. H. O'Brien.
J. A. Parsons.
E. W. Quinn.
J. H. Remick.
G. A. Sampson.
A. L. Sawyer.
J. E. Sheldon.
C. W. Sherman.
J. W. Smith.
G. T. Staples.
J. T. Stevens.
G. A. Stowers.
J. F. Sullivan.
A. H. Tillson.
R. S. Weston.
G. C. Whipple.
F. H. White.
J. C. Whitney.
G. E. Winslow.
I. S. Wood.
H. D. Woods. — 53.

Associates.

Harold L. Bond Co., G. S. Hedge.
Builders Iron Foundry, A. B. Coulters.
A. M. Byers Co., H. F. Fiske.
Chapman Valve Mfg. Co., J. J. Hartigan.
V. N. Bengle, W. U. Storrs, J. P. Mulgrew, and C. E. Pratt.
Darling Pump & Mfg. Co. (Ltd.), H. A. Snyder.
Garlock Packing Co., L. S. Harris, C. D. Allen.

Goulds Mfg. Co., Creed W. Fulton.
Hersey Mfg. Co., W. A. Hersey, J. H. Smith.
Leadite Co., George McKay, Jr.
Lead Lined Iron Pipe Co., T. E. Dwyer, Wilfred Poor.
Edson Mfg. Co., H. L. B. Watson.
Ludlow Valve Mfg. Co., A. R. Taylor, G. A. Miller.
Mueller Mfg. Co., G. A. Caldwell.
National Meter Co., J. G. Lufkin, H. L. Weston.
Neptune Meter Co., H. H. Kinsey.
Norwood Engineering Co., F. M. Sears.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., F. E. Hall.
Water Works Equipment Co., W. H. Van Winkle.
R. D. Wood & Co., H. M. Simons.
Worthington Pump & Machinery Corporation, Samuel Harrison, W. T. Bird. — 34.

Guests.

Maine.

Portland, Edward Duddy.

New Hampshire.

Somersworth, C. F. Crockett.

Massachusetts.

Belmont, Mrs. C. W. Sherman.
Boston, Mr. and Mrs. D. A. Ambrose, Mr. and Mrs. J. G. Andrews, Mr. and Mrs. S. E. Thompson, Mr. and Mrs. W. W. Clifford, E. P. Bliss, T. F. Dorsey, A. L. Gammage, C. F. Glavin, Miss Joan M. Ham, Mrs. W. S. Johnson, Mrs. H. H. Kinsey, E. F. Sullivan, J. A. Tomasello.
Braintree, Mrs. W. E. Maybury, L. W. Thayer.
Bridgewater, Mrs. John Mayom, Miss Bulah Hopkins.
Brookline, Mrs. R. S. Weston, Mrs. H. B. Burley.
Canton, C. V. Reynolds.
Dedham, Mrs. F. J. Gifford, Miss S. K. Staples.
Framingham, Mrs. W. T. Howland.
Holyoke, Mrs. F. M. Sears.
Melrose, Mrs. C. F. Knowlton, Charles Knowlton, Jr.
Methuen, Miss Violet Appleyard.
Needham, P. D. G. Hamilton, Mrs. Peter Hamilton.
Newton, Miss Carol Childs, C. D. Bryant, W. P. Morse, Miss Beatrice Slattery.
Northampton, C. P. Houghton.
Norwood, G. A. Smith.
Palmer, Mrs. F. C. Gamwell.
Reading, Mrs. L. M. Bancroft.
Revere, Mr. and Mrs. G. R. Burnes, Mr. and Mrs. H. T. White.
Wellesley, Mrs. W. A. Hersey, Francis Hersey, W. P. Hersey.

Rhode Island.

Narragansett Pier, Mrs. Willard Kent.
Newport, Miss Marion L. Ober, A. J. Ober.

New Jersey.

Trenton, Mrs. Alvin Bugbee. — 55.

On recommendation of the Executive Committee, the following applicants for membership were by unanimous vote made members of the Association:

Walter Elwood MacDonald, city water works engineer, Ottawa, Canada; Herbert T. White, water registrar, Revere, Mass.; and Robert C. Wheeler, civil engineer, Philadelphia, Pa.

A letter from George C. Whipple, president of the Boston Society of Civil Engineers, recommending the adoption by the Association of a resolution favoring Prohibition during the continuance of the present war, together with a letter of endorsement from Caleb Mills Saville, President of this Association, was presented, and it was unanimously voted:

Whereas, on account of a state of war it is necessary that this country conserve its sources of food supply to the utmost; and

Whereas, immense quantities of grain, molasses, and other food products are now used in the manufacture of distilled and fermented liquors,

Be it resolved, that the members of the New England Water Works Association present at this meeting favor such congressional action as will result in the prohibition of the manufacture and sale of distilled and malt liquors in the United States during the continuance of the war; and

Be it resolved, that copies of this resolution be sent to the President of the United States and the Senators and Representatives who represent the New England States in Congress.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

NOVEMBER MEETING.

THE BOSTON CITY CLUB,
BOSTON, MASS., November 14, 1917.

Mr. Caleb M. Saville, President, presiding.
The following members and guests were present:

HONORARY MEMBERS.

E. C. Brooks.	Desmond FitzGerald.	George A. Stacy.
R. C. P. Coggeshall.	Frank E. Hall.	Robert J. Thomas. — 6.

MEMBERS.

L. M. Bancroft.
C. R. Bettes.
J. W. Blackmer.
J. C. Chase.
F. L. Cole.
J. E. Conley.
J. H. Cook.
John Cullen.
F. A. Darling.
A. O. Doane.
E. D. Eldredge.
R. H. Ellis.
S. F. Ferguson.
F. L. Fuller.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
C. R. Hildred.
D. A. Heffernan.
J. L. Howard.
A. C. Howes.
W. T. Howland.
G. A. Johnson.
M. S. Kaharl.
Willard Kent.
S. E. Killam.
G. A. King.
P. J. Lucey.
W. J. Lumbert.
C. E. McDonald.
Hugh McLean.
H. V. Macksey.
A. E. Martin.
John Mayo.
F. E. Merrill.
M. L. Miller.
W. H. O'Brien.
T. A. Peirce.
H. E. Perry.
H. G. Pillsbury.
C. R. Preston.
E. W. Quinn.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
J. E. Sheldon.
G. A. Stowers.
J. F. Sullivan.
H. A. Symonds.
L. D. Thorpe.
E. J. Titcomb.
D. N. Tower.
W. H. Vaughn.
G. E. Winslow.
L. C. Wright. — 55.

ASSOCIATES.

Harold L. Bond Co., F. M. Bates, F. W. Mattheis.
Builders Iron Foundry, A. B. Coulters.
Central Foundry Co., W. S. Feltt.
Chapman Valve Mfg. Co., H. H. Cook, J. T. Mulgrew, C. E. Pratt.
Hayes Pump & Machinery Co., F. H. Hayes.
Hersey Mfg. Co., J. Herman Smith.
Kennedy Valve Mfg. Co., J. S. Hanlon.
Lead Lined Iron Pipe Co., T. E. Dwyer.
Ludlow Valve Mfg. Co., A. R. Taylor.
National Meter Co., J. G. Lufkin, H. L. Weston.
Neptune Meter Co., H. H. Kinsey.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., H. W. Jacobs, D. K. Otis, E. K. Otis.
Warren Foundry & Machine Co., W. F. Woodburn.
Water Works Equipment Co., W. H. Van Winkle, Jr.
Worthington Pump & Machinery Corporation, W. F. Bird, Samuel Harrison, E. P. Howard. — 27.

GUESTS.

MASSACHUSETTS.

Boston, George A. Caldwell, G. Ferullo, Eugene F. Leger.

CONNECTICUT.

Hartford, J. F. Shaughnessy, Asst. Engineer, Hartford Water Works.

—4.

THE PRESIDENT. Since our last meeting the Association has met with a great loss in the death of one of its most active and useful members, and it seems fitting that before we begin our regular exercises we should pay some tribute to his memory. I will now call on Mr. Coggeshall to say a few words concerning our late associate, Mr. W. S. Johnson.

MR. R. C. P. COGGESHALL. *Mr. President and Fellow Members,* — Death has been very busy in our ranks of late. We were all shocked by the terrible tragedy that occurred in the early part of the year. Then war came and took from our service our Editor, Colonel Hale, and the Executive Committee selected Mr. Johnson to attend to the work he had left. But hardly had Mr. Johnson got started in the work than he was overtaken by sickness, right in the midst of the preparation of the number of the JOURNAL which you received a few days ago, and he passed away from us. I was not fortunate in knowing Mr. Johnson as intimately as many of you did, but I was engaged with him in committee work during the last two or three years, and I found him very thorough and very painstaking, and I recognized him, as we all did, as a man whose promise for the future was bright. Now he has gone from our midst, and I wish that we might fittingly express our sorrow and our sense of loss. I would suggest, Mr. President, that we all rise and stand for a few moments in silence while our thoughts turn to the memory of our departed friend.

[The members all rose and stood in impressive silence for a few moments.]

THE PRESIDENT. The first business before the Association is in connection with matters which the Secretary has in hand, and I will call upon him to present it.

The Secretary read the following names of applicants for membership, all properly endorsed and recommended by the Executive Committee:

Resident: G. Ferrullo, Boston, Mass., contractor, constructing water works: Herbert M. Tucker, Lebanon, N. H.; manager Hartford Water Company water works, White River Junction, Vt.

Non-Resident: A. A. Laflin, St. Stephens, N. B., superintendent water works; Charles Sing Denman, Des Moines, Ia., general

manager Des Moines Water Company; Vratislav Adolph Zehr, civil engineer, Wilkinsburg, Pa.

Associate: Eugene F. Leger, Allston, Mass., installation of pumping and sewage plants (Power Equipment Company).

On motion of Frank L. Fuller, the Secretary was directed to cast one ballot in favor of the applicants, and he having done so they were declared duly elected members of the Association.

Proposed Amendment to the Constitution.

The Secretary. The Executive Committee at its session to-day voted to recommend the following amendment to the Constitution of the New England Water Works Association:

Strike out the whole of Section 2 of Article IV and make it to read as follows:

Sect. 2. The annual dues shall be —

For Members,	$5.00
For Associates,	25.00

That is, in effect, raising the dues of the active members from $3 to $5, and of the associates in the same proportion from $15 to $25. The article in relation to dues now reads:

Article IV.

Dues.

Section 1. The initiation fee shall be —

For Resident Members,	$5.00
For Non-Resident Members,	3.00
For Associates,	10.00

Sect. 2. The annual dues shall be —

For Members,	$3.00
For Associates,	15.00

In order to amend the Constitution the requirement is:

Article IX.

Amendments.

Section 1. Proposed amendments to this Constitution must be submitted in writing to the Executive Committee, and shall be presented to the Association at a regular meeting, if so decided by a vote of the committee. It shall be the duty of the Executive Committee to bring before the Association any proposed amendment at the written request of ten members.

Sect. 2. Announcements of a proposed amendment which is recommended by the Executive Committee, or by ten members of the Association, shall be given by printing the amendment in the notices of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of an amendment.

THE PRESIDENT. It is in pursuance of the requirements of the Constitution that this amendment has been read at this time, and proper action will be taken, of course, at the next regular meeting of the Association.

PRESENTATION OF THE DEXTER BRACKETT MEMORIAL MEDAL FOR THE YEAR 1916.

MR. DESMOND FITZGERALD. *Mr. President and Fellow Members,* — The next matter on your program is the presentation of the Dexter Brackett medal awarded for the paper which was selected by the committee as the one among those published in the 1916 Proceedings most worthy of it. This is a most interesting occasion for me, and I believe it is for all of you, for two reasons: First, because this act of yours is starting a long historical list of members who will receive this medal in the future; and I believe that it will be an honorable list. In the second place, it is particularly interesting to me because the award has been made to your President who sits immediately at my left, which arrangement makes it very easy for me, because when I hand the medal over to him I shall not even have to take a step to do it.

The first award of the Dexter Brackett medal to Caleb Mills Saville, for his paper entitled, "Some Water Works Experiences in Hartford, Conn.," was announced at the September meeting of this Association. The paper was accompanied by diagrams showing losses of head in 4-in. and 6-in. pipes, which had been in service from thirteen to fifty years, together with tests on centrifugal pumps, fire hydrants, and check valves, besides other interesting data.

Since the award was published the medal has been cast, and it is now in order to make the formal presentation of the medal to Mr. Saville, which, owing to my long association with Mr. Brackett of forty-two years and with Mr. Saville later in the

Metropolitan Water Works, becomes a particularly pleasant duty for me to perform.

The medal was designed by Mr. Theodore Spicer-Simson, of New York, under the supervision of Messrs. Stearns, Hazen, Flinn, and Stacy, of this Association. This is a bronze medal, about 3 in. in diameter, so that Mr. Saville, or any of his successors in the award, need not hesitate to keep it in his desk or at his home. Had the medal been made of gold, this could not be done without danger of losing the medal by theft, a contingency which accompanies the Norman gold medals of the American Society of Civil Engineers, and which makes it necessary that they shall be kept in some safety deposit vault.

On the obverse of this Brackett medal is an excellent likeness of Mr. Brackett, whose kindly face was familiar to you all, with his name and the period covered by his life, 1851 to 1915. I think no one can fail to recognize this as a very excellent likeness of Mr. Brackett. On the reverse of the medal is a very appropriate device, a fountain in the shape of a pyramid, with three basins, one above the other; and surrounding it, on the outside, is the name of this Association in large letters, — " New England Water Works Association." And in connection with that inscription is the name of Mr. Saville, to whom the medal is presented. Close to the fountain are the words " For the most meritorious paper, 1916."

Now, in behalf of the committee appointed to make the award of this medal, I take great pleasure in handing it over to our excellent President, Mr. Saville, and I know that it will be treasured by him all through his life. [*Applause.*]

President Saville. *Mr. Chairman and Gentlemen of the Association,* — It is with peculiar gratification that I receive this medal which it has been your pleasure to hand to me. Several emotions stir me as I receive it, the least of which is due to the fact that my paper was chosen among many excellent papers. The greatest pleasure that comes to me is from the fact of my own long personal association with Mr. Brackett. Mr. Brackett was more than a chief to me; he was a personal friend. For about twenty years I was associated with him, going to the Metropolitan Water Works at a time very shortly after he went there, going

with two others at about the same time, members of this Association, and we three — Mr. John L. Howard and Mr. W. E. Foss and myself — being at that time Mr. Brackett's chief assistants. Mr. FitzGerald also was there, and that fact makes it particularly pleasant for me to receive this medal from his hands.

Mr. Brackett you all knew, and it is not for me to say anything about his work, but I would think of him as I knew him in the later part of his life, as a very, very dear friend. You know how his face would light up when you went in to see him, and it is with that appreciation of him that I am glad to have this medal. I thank you for it, gentlemen, and I thank you very sincerely. [*Applause.*]

There is one other matter of business at this time, and that is the report of Mr. William F. Woodburn upon matters under his charge at the last annual convention.

REPORT OF EXHIBIT COMMITTEE — HARTFORD CONVENTION, 1917.

BOSTON, MASS., October 3, 1917.

Mr. CALEB MILLS SAVILLE, *President*,
NEW ENGLAND WATER WORKS ASSOCIATION,
HARTFORD, CONN.

Dear Sir, — I am pleased to submit the following report of the Exhibit Committee's work at Hartford.

Owing to the war and other unusual conditions prevailing this year, our exhibit was not as large as at some other conventions, but I feel safe in saying that the interest displayed by the delegates was greater than at any exhibit I have ever attended, and many of the exhibitors advised me that it was the most successful exhibit from a business standpoint that they had ever attended.

The following of our associate members made exhibits, a total of 40:

American Bitumastic Enamels Co.
The American City.
Builders Iron Foundry.
Central Brass Mfg. Co.
Central Foundry Co.
Chapman Valve Mfg. Co.
Chicago Pneumatic Tool Co.
Joseph Dixon Crucible Co.
Eddy Valve Co.
Electro Bleaching Gas Co.
Engineering News-Record.
Fire and Water Engineering.

Goulds Mfg. Co.
Hersey Mfg. Co.
Kennedy Valve Co.
The Leadite Co.
Lead Lined Iron Pipe Co.
Lock Joint Pipe Co.
Alexander Milburn Co.
Municipat Journal.
National Meter Co.
National Water Main Cleaning Co.
Neptune Meter Co.
Norwood Engineering Co.
The Pitometer Co.
Pittsburgh Meter Co.
Pratt & Cady Co., Inc.
H. Mueller Mfg. Co.
Chris D. Schramm & Son.
A. P. Smith Mfg. Co.
Thomson Meter Co.
Union Water Meter Co.
United Brass Mfg. Co.
Wallace & Tiernan Co., Inc.
Warren Foundry and Machine Co.
Water Works Equipment Co.
R. D. Wood & Co.
Worthington Pump and Machinery Co.
S. E. T. Valve and Hydrant Co.
United States Cast Iron Pipe and Foundry Co.

(Signed) WM. F. WOODBURN,
Chairman Exhibit Committee.

On motion, duly seconded, the report was accepted and the committee was given a rising vote of thanks.

The President then called on Mr. J. H. Shaughnessy, assistant engineer, Hartford Water-Works System, who presented a paper on the "Construction of Earth Dam on Phelps Brook, Hartford's Water-Works System." After the reading of the paper, President Saville gave some further information in regard to the work.

Mr. Henry A. Symonds read an experience paper, contributed by Mr. A. N. French, superintendent of water works, Seneca Falls, N. Y., on "A Small Water-Works Testing Laboratory." The paper was accompanied by the following letter:

SENECA FALLS, N. Y.,
October 30, 1917.

WILLARD KENT, *Secretary*,
N. E. W. W. ASSOCIATION:

Dear Sir, — I am enclosing a little tale of experience which you are at liberty to present at some winter meeting of the Association, if you think it worth while. I will leave it to your judgment. If you do not think it will be of enough interest to have it read, I shall find no fault.

I am sorry that I cannot attend any meetings, these days, but the distance is too great.

Very truly yours,

(Signed) A. N. FRENCH.

Mr. French's paper was discussed by Mr. Robert Spurr Weston and President Saville, who in closing his remarks said:

"I think, as long as we are on this matter, the Association would be interested in hearing some of Mr. FitzGerald's experiences. Mr. FitzGerald is really the father, in a way, of water-works laboratory investigations. I think the laboratory at the Chestnut Hill Reservoir was where first were begun some of the investigations that have become classic, and some of the men that started in their work there have since made national reputations for themselves. If Mr. FitzGerald will tell us a few of his experiences, I think it will be very interesting." (*Applause.*)

MR. DESMOND FITZGERALD. It is an interesting thing for an old war horse like myself to know that the young fellows are having very much the same kind of troubles to-day that we had way back in 1873, which was the first year that I went to the Boston Water Works. It fell to my lot really, as your President has said, to start the first laboratory in this country — or in any country, I believe — especially for water-works investigations. But we had lots of troubles, back there in 1873, and along up through the eighties, with the Boston water, and the funny part of it was that the experts in those days couldn't tell us anything about what the causes of those troubles were. We would frequently have the water in such bad condition that you couldn't even clean your teeth with it with any degree of pleasure. It was due to the growth of asterionella, as we found out after awhile, but at that time there wasn't any expert chemist or physicist we could find — and we even went down to Johns Hopkins — who

could really tell us what the trouble was or what to do to remedy it. We were having at that time, I think, an income of about $2 000 000 from our works, and I thought that if the Boston Water Board would give me about $10 000 a year I could try to see if I couldn't find out for myself. The Board very kindly gave me that money.

Now I haven't time, in the five or ten minutes your President has given me, to tell you all about the troubles we had, — what we had to do and what we found out, and how interesting it all was, — but I will tell you one little incident that happened at one time, which came into my mind a moment ago. I wonder if anybody else here has ever had the same sort of experience. We were very short of water — and what town or city has not been in that condition? But I was very young and it worried me a great deal, this idea of supplying a city of two or three hundred thousand population from a lake which was only good for about 12 or 13 million gallons a day, and they were using 16 or 17 millions, and rapidly mounting to 20. Well, I told one of the old officials on our works that I couldn't sleep at night, thinking of the dangers that this great city with all its wealth was undergoing, for I knew that at any time a drought might come which would knock out the supply. " Well," said he, " after you have been on the works thirty or forty years, as I have been, you will go to sleep soundly at night and not worry." [*Laughter.*]

We were running the old Cochituate aqueduct, at that time, under just sufficient head to get the water down to the Chestnut Hill Reservoir. We had a drought, and one day the water began to go down below the top of the aqueduct, and that was a time when I thought I was justified in losing some sleep. After a while it got down to the middle of the aqueduct, and it was going so rapidly that I built a platform out in the middle of the lake and set up some centrifugal pumps and pumped the water into the aqueduct to keep it full. Finally the water in the lake got below the bottom of the aqueduct, and at the same time the papers in Boston were charging the engineer in charge of the works with drawing off the water at the outlet of Lake Cochituate for the sake of getting a $5 000 000 appropriation for the Sudbury River works. That was a most disturbing thing. [*Laughter.*]

Now I am going to tell you of something which happened one night. It took both of those pumps to keep the water running at the rate of 20 000 000 gal. per day through the aqueduct, pumping from the deeper portion of the lake up over the stop-planks into the aqueduct. One night, as I was going to bed, I got a telegram saying one of the pumps had gone out of commission, but that the aqueduct was still full of water. In other words, one pump with a capacity of 18 000 000 gal. a day was filling that aqueduct which was carrying 20 or 22 million. Well, I got up and harnessed my own horse, as we did in those days, and drove up there in the middle of the night, and there was the aqueduct full, the water coming down as usual, and one pump only keeping it full. In other words, that one pump was pumping about 16 million gallons a day, and 22 millions were going down the aqueduct. Well, I was about at my wits' end, but I was bound to find out. It was in the middle of the winter, one of the most severe winters we had ever had. I ordered the pump stopped, and the water fell, and then I put a small boat in, with one of my best men in it, and another man with him, and sent him down to find out what the trouble was; and after they had gone down some ways they heard a roar like Niagara; and they went on a little further and they found a stream of water coming down into the aqueduct, about $2\frac{1}{2}$ ft. in diameter, a solid sheet of water, from the outside coming directly into the aqueduct and filling it quite full. Well, that was a poser. So I sent them in again to get the exact position of the station, and they came back with it; and then I sent other men down to find out where the water was coming from on the outside, and they all came back and reported that they couldn't see a thing; that there wasn't any water flowing down. Well, what would you have done under those conditions? Of course I went down myself, and I found the exact point, and I found it was in a heavy cut, and that the ice in this cut was very thick indeed. I immediately sent for choppers, and we cut a hole and we found the ice was two or three feet thick. Then the whole thing became apparent to me. There was a brook going down through this cut, and the brook had a larger amount of water than usual flowing in it, but the ice had frozen over the top of it and the ice had risen and given the brook a chance to flow under-

neath, which was very accommodating. And when we got down through that ice, two or three feet thick, — it had been freezing in layers, as more water came on top it froze, — and finally it got such a grip on the manhole of the aqueduct that it lifted the manhole and part of the brickwork off with it, and allowed the water of the brook to flow down. [*Laughter.*]

Now, gentlemen, I think you will agree with me that that is the easiest way of getting a water supply you ever heard of. But how about the quality? Well, I didn't stop to find out about the quality. But the difficulty of getting that place fixed up and the water stopped you may imagine, in the dead of a severe winter. But that is one of the interesting little incidents that occurred to me, and I am very sorry that I cannot stay longer with you and tell you some more stories. If you will invite me up here some time to a good dinner like this, however, I will agree to tell you some more. [*Applause and laughter.*]

The President. The Secretary says that you have a standing invitation. [*Applause.*]

Mr. FitzGerald. Thank you, I had rather have a sitting one. [*Laughter.*]

The President. We have about fifteen minutes more before we must give up this room. We haven't heard anything from our friend from Holyoke for a long while, and if Mr. Gear will tell us about some of his experiences up there I know we shall all go away feeling very happy. [*Laughter.*]

Mr. Patrick Gear. Mr. President, I don't know what kind of a story I can tell you; but, referring to the first subject we had here to-day, presented by Mr. Coggeshall, I never knew Mr. Johnson died until this morning. I got acquainted with him a year ago; he was in Holyoke two or three times, and this Society has lost a good friend. He was a conscientious worker for anything he was ever asked to do, and I was sorry when I met him in Hartford and saw he wasn't very well, and I was more sorry when I heard to-day he had passed away. I have heard Mr. Johnson read papers at this convention, and no matter what kind of a subject he took up he always went into it very thoroughly. If he had had a paper last year I think he would have been a strong competitor with our President for the Brackett memorial, because he always went very thoroughly into any subject he took up.

We haven't been doing very much work up in Holyoke this year, but I happened to think, when the gentleman was speaking a little while ago, that we built a dam in Holyoke, and I think I will ask our engineer to tell you about it at some time. He had some difficulty in carrying his machine along and dumping his concrete into his forms. I went up there one day and they were getting it up a steep platform. Help was scarce, — it was hard to keep them out in the woods, twenty miles from anywhere. And I was pleased when I saw the engineer had arranged a tandem to run the wheelbarrows up the platform. I don't know as I ever saw a tandem of that kind before, one man ahead pulling and another man behind pushing; but it was a successful tandem, and it was the only way he could hold the men to the work, to have this tandem team running up a wheelbarrowful of concrete. The job is finished now, and if anybody from the Association will come to Holyoke I will guarantee to take him out there and show him a nice little job of concrete and give him a good dinner, and it won't cost him a nickel. [*Applause and laughter.*]

Adjourned.

December Meeting.

Hotel Brunswick,
Boston, Mass., December 12, 1917.

The President, Mr. Caleb M. Saville, in the chair.

The following members and guests were present:

Honorary Members.

Edwin C. Brooks.	Desmond FitzGerald.	Robert J. Thomas. — 5.
R. C. P. Coggeshall.	Frank E. Hall.	

Members.

L. M. Bancroft.	A. E. Blackmer.	F. L. Cole.
F. A. Barbour.	J. W. Blackmer.	H. S. Crocker.
J. F. Barrett.	H. R. Buck.	John Cullen.
G. W. Batchelder.	J. C. Chase.	F. A. Darling.
F. W. Bateman.	H. W. Clark.	C. E. Davis.

J. M. Diven.
A. O. Doane.
E. D. Eldredge.
G. Ferullo.
F. L. Fuller.
G. W. Fuller.
Patrick Gear.
F. J. Gifford.
P. T. Gray.
T. G. Hazard, Jr.
D. A. Heffernan.
J. L. Howard.
A. C. Howes.
J. A. Hoy.
W. F. Hunt.
J. L. Hyde.
Willard Kent.
S. E. Killam.
G. A. King.
P. J. Lucey.
C. E. MacDonald.
F. A. McInnes.
H. V. Macksey.
W. E. Maybury.
John Mayo.
J. H. Mendell.
Leonard Metcalf.
C. E. Peirce.
T. A. Peirce.
H. G. Pillsbury.
C. R. Preston.
C. L. Rice.
G. A. Sampson.
H. W. Sanderson.
C. M. Saville.
A. L. Sawyer.
J. E. Sheldon.
C. W. Sherman.
G. H. Snell.
H. A. Symonds.
Milton Thorne.
E. J. Titcomb.
D. N. Tower.
W. H. Baughn.
I. S. Wood.
M. B. Wright. — 61.

ASSOCIATES.

Harold L. Bond Co., F. M. Bates, H. H. Sinclair.
Builders Iron Foundry, A. B. Coulters.
Byers, A. M. Co., H. F. Fiske.
Central Foundry Co., R. W. Conrow.
Chapman Valve Mfg. Co., C. E. Pratt.
Chicago Pneumatic Tool Co., F. S. Eggleston, Jr.
Donaldson Iron Co., C. F. Glavin.
Eddy Valve Co., H. R. Prescott.
Garlock Packing Co., C. D. Allen.
Hammond Process Co., P. J. Pickett, J. L. Flinn.
Hayes Pump & Machinery Co., F. H. Hayes.
Hersey Mfg. Co., J. H. Smith, W. A. Hersey.
Ludlow Valve Mfg. Co., G. A. Miller.
National Meter Co., J. G. Lufkin, H. L. Weston.
Neptune Meter Co., H. H. Kinsey.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., D. K. Otis, H. W. Jacobs.
Warren Foundry & Machine Co., W. F. Woodburn, J. H. Morrison.
Water Works Equipment Co., W. H. Van Winkle.
R. D. Wood Co., Charles R. Wood.
Worthington Pump and Machinery Corporation, Samuel Harrison. — 30.

GUESTS.

MASSACHUSETTS.

Boston, George A. Caldwell.
Fall River, H. C. Bryant.
Brockton, Frank H. Kennedy.

RHODE ISLAND.

Providence, J. D. Savage.
East Greenwich, James Kinlock. — 5.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

Non-Resident: Frederic E. Beck, Utica, N. Y., engineer consolidated Water Co., Utica; John Y. Lavery, Summit, N. J., city engineer.

Associate: Donaldson Iron Co., Emaus, Pa.; Hammond Process Co., Boston, Mass., paint manufacturers.

On motion of Mr. Coggeshall, the Secretary was empowered to cast one vote in favor of the admission of the applicants named, and, he having done so, they were declared elected members of the Association.

The President called upon Mr. McInnes to present the report of the Committee on Cast-Iron Pipe Specifications. Mr. McInnes stated that owing to circumstances over which the committee had had no control they were not ready to make a report at the present time, but hoped to be able to report at the next meeting of the Association.

THE PRESIDENT. The next business is action on the proposed amendment to the Constitution by striking out the whole of Section 2, Article IV, so that it will read as follows:

Sect. 2. The annual dues shall be —

For Members,	$5.00
For Associates,	25.00

I will say that the Executive Committee referred this matter to the Committee on Finance, of which Mr. Leonard Metcalf is chairman, and I will ask him to make a statement in regard thereto.

MR. LEONARD METCALF. *Mr. President and Gentlemen,* — I think perhaps the briefest way of presenting this to you will be to read the report which was made to the Executive Committee:

BOSTON, MASS., December 1, 1917.

TO THE EXECUTIVE COMMITTEE OF THE
NEW ENGLAND WATER WORKS ASSOCIATION,
TREMONT TEMPLE, BOSTON, MASS.

Your Committee on Finance, of the Association, have given careful study to the revenue and expenditures of the Association during the past, — in particular the past seven years; to its present condition, and the probable

figures for the uncompleted year 1917; and have made an estimate of the revenue and expenditures for the year 1918. The figures developed are appended hereto.

An examination of these figures, and the more distant financial history of the Association, indicates that for a number of years the revenue and expenditures were approximately balanced, — an excess of revenue in one year being counterbalanced by an excess of expense following. Since the year 1912, however, the excess of revenue over expense has been dwindling, and the available resources of the Association have suffered material loss, without hope of recovery if the past activities of the Association are to be maintained.

The excess of revenue in the years 1911 and 1912 but little more than offset the deficit of the year 1910. In the year 1913 a small deficit was incurred, which was not quite offset by the surplus of 1914. In the year 1915 a very substantial excess of expenditures over revenue was incurred, including some figures carried forward from the previous fiscal year on account of the JOURNAL; in the year 1916 revenue and expenditures balanced, and for the current year the revenue will again be materially less than the anticipated expenditures, as will be the case in the year 1918 upon the present revenue basis.

The estimate for the year 1918 indicates that the revenue, predicated on the present annual dues and necessary expenditures, will fall below the expenditures by from $800 to $1 200. This estimate is based on the assumption that strict economy will be exercised, and that all proposed expenditures will be carefully scrutinized and unnecessary items eliminated. To reach even these figures greater economy will have to be observed than has been common to the Association during recent years. It is possible, perhaps probable, that costs will increase as the years go by, and make deficits, with the present revenue scale, even greater in succeeding years.

If the Association is to make both ends meet, it will therefore be necessary either to curtail the present activities of the Association as well as to maintain strictest economy, or to find new sources of revenue through increase in advertising income or charges to members.

While strict economy should, of course, be observed, it does not seem desirable to your committee to attempt to curtail the field of activity of the Association. It does not seem practicable to increase the revenue by increase in advertising rates, and experience does not indicate that a large increase in amount of advertising can be hoped for. It appears to your committee, therefore, that it is the part of wisdom to increase the annual dues, and, in view of the method adopted for meeting the substantial expenses of the annual convention, it appears desirable that the increase in dues should be limited to the members rather than to the members and associates.

For the year 1918 it is probable that the revenue and expenditures can be approximately balanced if the dues of active members are increased from $3 to $4 per year, — the dues of associates remaining unchanged. It is possible that in view of the condition of the times it may prove desirable to ask for a voluntary subscription of $1 each, in excess of the suggested $4 annual dues,

from such members as may feel in a position to make such contribution, and your committee is not at all confident that this increase will be sufficient for future years; but the committee deems it wiser to make the transition from the present dues to whatever figure may prove necessary for the future, by steps, rather than to make the more radical increase in dues from $3 to $5 for members or to add to the dues of associates at the present time.

The committee therefore recommends that the Constitution be amended by changing the amount of the annual dues of members from $3 to $4, and that the Executive Committee be authorized to ask for voluntary contributions from members of the sum of $1, should it appear more desirable to call for such subscription than to attempt to market the securities owned by the Association at the present time.

Respectfully submitted,

LEONARD METCALF.
CHARLES W. SHERMAN.
H. V. MACKSEY.
LEWIS M. BANCROFT.
R. C. P. COGGESHALL.
CARLETON E. DAVIS.
WILLARD KENT.
C. M. SAVILLE.
S. E. KILLAM.

Mr. Metcalf, in explanation of the report, stated that the committee favored making dues for active members $4, but feared dues of $5 might affect membership under present conditions. No increase was advised in dues of associate members, owing to large contributions from them at the conventions.

It was suggested that economy might be effected by eliminating music at dinners and leaving it to the members who smoke to furnish their own cigars, the amount of such annual saving being $50 to $60 for cigars and $100 to $120 for music. Further economy was practicable through cutting out unessential material from the JOURNAL, some organizations having considered suspending publications of their journals during the period of the war. A possible economy might be omitting the luncheons as a feature of the meetings.

Mr. Metcalf expressed his personal opinion in favor of continuing the activities of the Association virtually as in the past, and that it was particularly important at present for water-works men to get together to discuss the new problems which arise, due

Condensed Statement.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917 to Oct. 31.	Estimated Forecast. 1917 Total.	Estimated Forecast. For 1918.
Revenue:										
1. Members	$3 145	$3 094	$3 064	$3 197	$3 732	$4 008	$4 546		$4 195	$4 000
2. JOURNAL	2 160	2 267	2 468	1 810	2 546	2 152	2 287		2 140	2 125
3. Miscel., dinners, certificates, etc.	1 014	889	1 116	895	1 187	958	1 048		915	825
Sub-total	$6 319	$6 250	$6 648	$5 902	$7 465	$7 118	$7 881		$7 250	$6 950
4. Dividends & interest	188	191	214	221	221	221	141		125	125
Sub-total	$6 507	$6 441	$6 862	$6 123	$7 686	$7 339	$8 022		$7 375	$ 7075
5. Mfrs. Assoc. for Conv.*	.....	.....	.....	.....	.....	.....	1 000		.....	.....
Total revenue	$6 507	$6 441	$6 862	$6 123	$7 686	$7 339	$9 022		$7 375	$7 075
Expenditures:										
1. JOURNAL	$3 603	$3 209	$2 358	$3 092	$3 401	$4 841	$3 340		$3 740	$3 785
2. Office	1 960	1 683	2 048	1 912	1 885	2 150	2 274		2 645	2 745
3. Meeting & committees	1 675	1 388	1 529	1 530	2 151	1 578	2 403		2 315	1 340
Sub-total	$7 238	$6 280	$5 935	$6 534	$7 437	$8 569	$8 017		$8 700	$7 870
4. Convention expenses*	.....	.....	.....	.....	.....	.....	1 000		.....	.....
Total expenditures	$7 238	$6 280	$5 935	$6 534	$7 437	$8 569	$9 017		$8 700	$7 870
Net revenue for year	−$731	$161	$927	−$411	$249	−$1,230	$5		−$1,325	−$795
Balance brought forward, January 1	3 450	2 719	2 880	3 807	3 396	3 645	2 415		2 420	1 095
Balance carried forward, December 31	$2 719	$2 880	$3 807	$3 396	$3 645	$2 415	$2 420		$1 095	$300

* Prior to 1916, the convention expenses were paid by contributions disbursed directly through the convention committee of the Association, and not through the Treasurer.

NEW ENGLAND WATER WORKS ASSOCIATION — COMMITTEE ON FINANCE.

November 26, 1917. ANNUAL REVENUE AND EXPENSE. Leonard Metcalf.

Year ending December 31.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917 to Oct. 31.	Estimated Total, 1917.	Estimate for 1918.
Honorary Members	13	12	12	12	11	18	17			
Members	678	680	666	686	766	862	942			
Associates	56	58	53	60	70	81	84			
Total membership	747	750	731	758	847	961	1 043			
JOURNAL — Volume	XXIV	XXV	XXVI	XXVII	XXVIII	XXIX	XXX			
Cost (4 issues)	$3 491	$2 626	$2 477	$3 586	$3 346	$4 243	$3 387			
Cost per page*	4.32	4.02	4.37	4.89	4.65	5.47	4.79			
Cost per member	4.78	3.50	3.35	4.81	4.17	4.68	3.38			
Number of pages, total	808	654	567	733	719	776	707			
Number of pages of text	643	475	401	554	564	596	538			
Copies printed	1 000	1 000	1 000	1 000	1 050	1 325	1 500			
Circulation at end of year	840	840	826	858	951	1 079	1 155			
Revenue:										
1. Members. Initiation fees	$275	$223	$197	$281	$619	$274	$682		$175	$150
Dues from members }	2 870	2 871	2 867	2 916	2 217	2 623	2 670		2 720	2 650
Dues from associated }					896	1 111	1 194		1 300	1 200
2. JOURNAL. Advertisements	1 736	1 764	1 839	1 371	1 988	†1 755	1 765		1 611	1 800
Subscriptions	168	183	213	258	243	213	231		110	150
Sales	196	279	266	149	215	142	265		399	150
Reprints	60	41	150	32	100	42	26		20	25
3. Miscellaneous. Receipts Pipe Specifications	44	62	41	31	43	20	33			
Dinners	950	821	670	670	1 035	837	708		850	800
Excursions	...	...	405	194	...	...	...		...	...
Certificates, buttons, miscellaneous	20	6	...	...	109	101	307		65	25
Sub-total	$6,319	$6 250	$6 648	$5 902	$7 465	$7 118	$7 881		$7 250	$6 950
4. Dividends and interest	188	191	214	221	221	221	141		125	125
Total revenue	$6 507	$6 441	$6 862	$6 123	$7 686	$7 339	$8 022		$7 375	$7 075
Manufacturers Association for Convention	...	...	...	...	...	...	†1 000		...	...
							$9 022			

Expenditures:										
1. JOURNAL. Advertising Agent	$237	$272	$250	$242	$239	$226	$239		$230	$200
Plates	74	146	71	318	142	188	98		70	75
Printing	2 541	2 117	1 215	1 638	2 019	3 452	2 067		2 600	2 500
Editor's salary	307	300	300	300	300	375	225		300	300
Editor's expense	23	52	31	37	43	48	35		30	35
Advance reports	...	...	...	169	90	19	131		30	100
Reporting	343	58	265	141	280	297	242		220	250
Reprints	25	222	197	190	253	161	225		160	200
Envelopes, postage, miscellaneous	52	42	29	57	35	75	78		100	125
2. Office, Secretary's salary	200	150	250	200	200	200	200		200	200
Secretary's expense	87	46	63	32	50	26	27		40	40
Assistant to Secretary's salary	600	600	600	600	600	600	800		890	1 080
Assistant to Secretary's expense	155	139	159	165	194	293	372		300	200
Rent	533	300	500	300	400	400	404		650	650
Printing, stationery, postage, miscel.	208	262	285	416	239	418	280		300	300
Membership lists	176	186	191	199	202	213	191		265	275
3. Meetings and Committees. Stereopticon	22	69	51	72	40	50	40		45	70
Dinners and incidentals	924	975	810	817	1 188	1 041	916		900	900
Printing, stationery, postage, library	304	208	161	178	637	299	894		190	300
Badges and tracing	52	56	47	78	...	21	117		...	...
Treasurer's salary and bond	68	68	68	68	68	68	68		70	70
Certificates of membership	...	...	...	...	125	51	26		...	...
Miscellaneous excursions	217	...	373	317	25	...	62		...	...
Miscellaneous committees	88	...	...	...	...	...	...		...	...
Miscellaneous expenses	...	12	19	...	68	48	21		...	...
Printing indexes	...	...	...	...	...	...	151		580	...
Reporting (exclusive of JOURNAL)	...	...	...	...	...	...	108		50	...
Furniture	...	...	...	...	...	...	...		480	...
Total expenditures	$7 238	$6 280	$5 935	$6 534	$7 437	$8 569	$8 017	...	$8 700	$7 870
Convention expenses	...	...	...	...	...	...	†1 000		...	...
							$9 017			
Net revenue	—$731	$161	$927	—$411	$249	—$1 230	$5		—$1 325	—$795
Balance brought forward January 1	$3 450	$2 719	$2,880	$3,807	$3 396	$3 645	$2 415		$2 420	$1 095
Balance carried forward December 31	$2 719	$2 880	$3 807	$3 396	$3 645	$2 415	$2 420		$1 095	$300

* See page 153, Vol. XXVII, 1913.

† Prior to 1916, the convention expenses were paid by contributions disbursed directly through the convention committee of the Association, and not through the Treasurer.

to present conditions. Probably little could be saved to the members by curtailing or doing away with the luncheons. It seemed advisable to continue the publication of the JOURNAL, but to do everything possible to condense information, and suggested that authors should be content with the thought that such a course is serving the best interest of the membership at large.

It is important not to increase dues more than absolutely necessary, for we want it to be just as easy and just as desirable as possible for all men, particularly the younger men, to join the Association and become active members.

On motion of Mr. Coggeshall, it was voted to receive the report.

Mr. Coggeshall then moved that the report be accepted.

Mr. Desmond FitzGerald suggested that the first step in retrenchment be the giving up of music at the dinners.

MR. CHARLES R. WOOD. It seems to me that the associate members might be able to stand an increase in their dues, and if you increase the dues of the active members to $4, I think the associate members should pay $20. I think $25 is too high. Speaking for my own company, I think we would be glad to pay $20 to help out the finances of the Association.

MR. CONROW. Speaking for my company, I agree with Mr. Wood, and I think we would be very glad to pay either $20 or $25, whichever the Association think they need.

Mr. J. M. Diven favored an increase of dues of active members to $5, rather than cutting down the JOURNAL, as the sole benefit of the Association to many members is the JOURNAL. Mr. Diven also spoke of the efforts of the associate members for the benefit of the Association, especially in time and money in entertainment and exhibits at the conventions, and suggested $15 for associate members' dues instead of $25.

Mr. METCALF. May I say a word in explanation of the effect of raising the dues. I did not read you a statement of the revenue and expense, which I assume will be published in the JOURNAL. We have at the present time something over 1 000 members. An increase of $1 in the dues would give us $1 000. The increased cost will vary between $800 and $1 200. Now, we have 84 associate members, so that an increase of $5 in the dues of the associate members would mean about $400. We felt that that might be

burdensome to some of the associates, so that we might lose them, and therefore the increase in the amount of associates' dues might not mean a very substantial increase in revenue to the Association. To meet Mr. Diven's point in regard to the JOURNAL, I think he misunderstood what I said. It is not the suggestion of the committee that the JOURNAL should not be published, or should be decreased in bulk arbitrarily, but merely that we should boil down the information which was contained in the papers and get rid of the redundant material.

MR. DIVEN. The dues of the American Water Works Association were increased from $3 to $5. At the time the membership was between 500 and 600, and the loss of membership by the increase was 11. I do not believe the increase here will make a difference of a dozen members.

Mr. Coggeshall's motion that the report of the committee be accepted was put and adopted.

MR. FITZGERALD. Now, Mr. President, in the line of economy, I move that during our dinners the music be dispensed with, at any rate, for the period of the war.

The motion was adopted by a rising vote of 39 to 22.

MR. MACKSEY. I now move that the members individually be accorded the privilege of purchasing their own cigars.

The motion was adopted.

THE PRESIDENT. The question will now be brought before the house whether this proposed amendment to the Constitution shall be acted on favorably or not. The proposed amendment is that the annual dues shall be for members $5, and for associates $25.

MR. DIVEN. I move to substitute $15 for $25, as the dues for associate members, leaving their dues as they are, and increasing the dues of the active members. Of course, the associate members will put it on our bills when they sell us anything. [*Laughter.*] I don't like to be so dependent on the associate members. I believe the active members should support the Association. The associates contribute a good deal, and if they want to contribute a little more, they can take an advertisement in the JOURNAL. I don't think any of them take such an advertisement now for the benefit they get from it, but it is more to help out the JOURNAL.

MR. MACKSEY. Mr. Chairman, I move you that the motion to amend the Constitution be amended, so that it shall read that the active members shall pay $4 and the associate members shall pay $20 per year.

THE PRESIDENT. Mr. Diven's motion was not seconded. The motion made by Mr. Macksey has been seconded, and it is now open for discussion.

MR. MACKSEY. The reason I make this motion is because there seems to be a diversity of opinion, some agreeing with the committee that the dues of active members should be increased $1, and that no increase should be made in the dues of the associate members; and some of the associate members, as you have already noticed, being in favor of bearing a fair share of the increased cost of running the Association, while the last speaker believes that the associate members are now paying enough. Gentlemen, this isn't a question of paying enough. I look at it this way: That the associate members of this Association are members of the Association. They have the interests of this Association as much at heart as the active members have, and if the cost of running this Association has increased so that somebody has got to bear the burden, I do not think the associate members intend to stand back and say, "Let the active members pay the bills, we are not going to pay any more." I do not expect to see them take that attitude at all. There is a certain additional amount of money to be raised if this Association is to live and pay its bills during the time that prices remain as they are.

I think you will bear me out when I say that the salaries of the active members of this Association have been increased but very little to meet the increased cost of living; whereas the cost of the goods manufactured by our associate members has been increased many, many times, and it makes very little difference whether the active members or their employers object to this increase or not, they must pay the bills if they want to get the goods. We all know the principle on which business is conducted is this: that all costs are charged to the goods, and if there is a dollar or two or five or ten dollars a year added on to the expense of selling the goods of a small concern, like the Mueller's, let us say, or the Ludlow Valve Company, or some concern of that kind,

it will disappear into the selling cost and will be figured when they figure how they will sell the goods.

It isn't fair to say that because the associate members, under the name of the Manufacturers' Association, I believe it is, contribute towards the running of the conventions, they should be allowed in here at a low rate. I don't believe in that at all. I believe they should pay their fair share of the running cost of this Association in their dues, where it will show. The officers of this Association and the officers of the Manufacturers' Association know about this contribution for the convention, but the average run of the members know very little about it, but they do know what is paid as dues. Now, I think that if, under the circumstances, the active membership will stand for a certain percentage of increase, the associate membership can stand for a similar percentage of increase. I have heard some talk that the representatives of some of the associate members say that if we charge any more they will get out. Well, gentlemen, if they think so little of their membership in this Association that $5 a year can drive them out, if they have so little sympathy with the aims of this Association that $5 a year will drive them out, I say to them, "Go, children, and God bless you; go as far as you can and as quickly as you can." [*Applause.*]

MR. DIVEN. As I understand the amendment now proposed, it will increase the revenue about $1 000?

MR. METCALF. Assuming no losses of membership.

MR. DIVEN. The losses will be inappreciable. Will that be sufficient to meet the deficiency?

MR. METCALF. It will be sufficient to meet the annual cost; it may not be quite sufficient to take care of the deficit of this year, and it was for that reason we suggested the other measure, giving the Executive Committee power to ask for contributions of $1 if they have to. An increase in the dues from $3 to $4 and from $15 to $20 would increase the income of the Association by about $1 400, assuming there were no losses in membership.

Mr. F. H. Hayes favored $15 as enough for the dues of the associate members.

Mr. Patrick Gear proposed separating the motion and allowing the associate members to vote on the section affecting their dues.

MR. MACKSEY. If there is no objection I will withdraw my original motion and make it as two motions. In the first place, I move as an amendment to the amendment of the Constitution now before the house, that the rate for the active members be set at $4 instead of $5.

The motion was adopted unanimously.

MR. MACKSEY. I now move as a further amendment to the amendment of the Constitution now before the house, that the dues for associate members be $20 instead of $25, as in the original amendment. And I move as an incidental motion that the associate members present be given the privilege of the floor to discuss this amendment.

It was voted to give the privilege of the floor to the associate members.

MR. WM. WOODBURN. I think most of the associate members would be perfectly willing to pay $20. It is a very small amount in the course of the year for the benefit we receive. And, not only that, I think very few appreciate the value of the JOURNAL as an advertising medium, and I think we should come out stronger in our support of the JOURNAL in advertising. When we are now taking a half or a quarter of a page, let us take a whole page, and make the JOURNAL the paper that it should be and more nearly self-supporting. I understand that the bulk of the deficit is on account of the JOURNAL, but I feel that the JOURNAL is a valuable advertising medium. Mr. Diven thinks it is more of a complimentary proposition on the part of the advertisers, but I know differently. The JOURNAL has a circulation of over 1 000 copies. It not only comes in and is read, but it is a paper that is filed away and is used for reference from time to time, and not only in New England, for but half of our membership, I understand, is in New England, and the other half is scattered all over the country. A man in southern California, for instance, wants to buy valves; he is a member of the Water Works Association, and he looks in the JOURNAL. I think we should get together and put our shoulders to the wheel and help on the advertising end.

Mr. Van Winkle expressed the belief that not six associate members present had authority to bind their firms.

MR. HAYS. I might say that I am one sixth of them, and I am willing to pay my $20.

Messrs. Coulters, Caldwell, Wood, and others, stated that they could speak for their firms, and believed most of the associate members present could. Expression was given of the appreciation of the value of the Association to their firms. All favored the proposed increase to $20.

Mr. Macksey's motion as an amendment to the amendment of the Constitution before the house, that the dues of associate members be $20 instead of $25, was adopted.

Mr. Sherman then moved that the amendment to the Constitution as amended by changing the annual dues of active members from $5 to $4, and those of associate members from $25 to $20, be adopted, so that it shall read as follows:

Sect. 2. The annual dues shall be —

For Members,	$4.00
For Associates,	$20.00

and this motion was adopted unanimously.

MR. METCALF. I will move that the Executive Committee be authorized to ask for contributions of one dollar from the members in case it finds it desirable to do so, to meet the present deficit, in preference to selling the securities of the Association at the loss which would be involved.

The motion was unanimously adopted.

MR. COGGESHALL. I have the interests of this Association at heart, the same as every one present has, and somehow or other I have got into the mood of giving, in common with all of you. There is scarcely a week goes by but we are asked to make a subscription to one fund or another fund. I have been very happy in the honors that this Association has given me in years past, and two years ago you made me an honorary member, so that I am free from dues. But I propose to send the Association within a day or two a check for $5 as a present from an honorary member, and perhaps some others will do the same. [*Applause.*]

THE PRESIDENT. The following letter has been received from Professor Swain, which I should like to read:

NOVEMBER 28, 1917.

My dear Mr. Saville, —

It seems most desirable for the good of the country that students in engineering schools who are drafted for service should, to such extent as may be possible, be detailed back to their respective schools to pursue their studies. Otherwise, we shall be seriously depleting our supply of trained applied scientists.

Enclosed is a copy of a letter which it is proposed to send to Secretary Baker. Signatures are being asked from the various technical schools, and they are desired from the presidents of the various engineering societies.

I earnestly hope that this will appeal to you and that you will sign the letter as president of your society and return it to me as soon as possible. If practicable, I should appreciate a telegram from you expressing your approval, so that if desired a single letter may be sent to Secretary Baker with all authorized signatures, leaving the individual letters to be sent later if desirable.

If you could secure favorable official action by your Board of Directors, it would also help.

I sincerely hope you will help in this movement.

Yours very truly,

(Signed) GEO. F. SWAIN.

MR. DIVEN. Action has already been taken by the War Department, so I am informed, doing this very thing.

On motion of Mr. Macksey, the communication was received and placed on file.

Mr. Frank A. Barbour, supervising engineer, gave a description, illustrated by stereopticon views, of recent construction work at the Ayer Cantonment, and Mr. Leonard Metcalf spoke of the wonderful work which has been done at Ayer and other camps.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association was held at Norumbega Park, Newton, Mass., Wednesday, June 13, 1917.

Present: Vice-President Samuel E. Killam, presiding, and members Frank J. Gifford, Lewis M. Bancroft, George A. King, Carleton E. Davis, and Willard Kent.

Three applications for membership were received, viz., Walter Elwood MacDonald, city water works engineer, Ottawa, Canada; Herbert T. White, water registrar, Revere, Mass., and Robert C. Wheeler, civil engineer, Philadelphia, Pa., and they were by unanimous vote recommended therefor.

The President was by vote authorized to appoint the following committees for the September convention, viz., — Committee on Literary Program, Local Members' Reception Committee, Ladies' Reception Committee, Citizens' Reception Committee, Associate Members' Committee.

A letter from Mr. George C. Whipple, president of the Boston Society of Civil Engineers, recommending the adoption by the Association of a resolution favoring Prohibition during the continuance of the present war, together with a letter of endorsement from Caleb Mills Saville, President of this Association, was presented, and it was voted that the adoption of said resolution be recommended to the Association.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., November 14, 1917.

Present: President Caleb M. Saville, and members Samuel E. Killam, Henry V. Macksey, Percy R. Sanders, Frank J. Gifford, Lewis M. Bancroft, George A. King, and Willard Kent.

Five applications for membership and one for associate membership were received and unanimously recommended therefor, viz.,

For Active: G. Ferullo, contractor, Boston, Mass.; Herbert M. Tucker, manager, Hartford (Vt.) Water Works, Lebanon, N. H.; Charles Sing Denman, general manager, Des Moines Water Co., Des Moines, Ia.; A. A. Laflin, superintendent Water Works, St. Stephens, N. B.; V. Adolph Zehr, civil engineer, Wilkinsburg, Pa.

For Associate: Eugene F. Leger, Allston, Mass.

A communication from the American Society of Mechanical Engineers, inviting this Association to appoint a delegate to attend a public hearing for the discussion of the Power Test Codes of that Society, was received, and the President was, by unanimous vote, authorized to appoint a delegate thereto.

A letter from Percival H. Mitchell, relative to the remission of dues of Lieut.-Col. C. H. Mitchell and other members of this Association now in active service in the Allied Armies, was presented, and, after discussion, it was unanimously voted that the Treasurer be and hereby is authorized to pay from the treasury of the Association the dues of members in active service during the continuance of the war.

The Secretary was directed to prepare a list of the names of members so engaged.

The Secretary was, by vote, directed to extend the thanks of the Association to non-members of this Association who contributed to the success of our convention of 1917.

The Secretary presented a letter from his assistant, requesting increased compensation for services; after discussion, on motion of Mr. Macksey, seconded by Mr. Gifford, it was *voted*, that the rate of compensation of assistant to the Secretary be ninety dollars per month, and that the duties include such assistance as the Editor and Advertising Agent require.

On motion of Mr. King, seconded by Mr. Killam, the President was authorized to appoint a special committee to consider the question of finances of the Association, and to make recommendations as to future methods of handling same. The President subsequently appointed as that committee Messrs. Leonard Metcalf, Charles W. Sherman, R. C. P. Coggeshall, Carleton E.

Davis, Samuel E. Killam, Henry V. Macksey, President Caleb M. Saville, Treasurer Lewis M. Bancroft, and Secretary Willard Kent.

Voted, that the thanks of the Association be given to Mr. Charles W. Sherman for his able and unrequited services rendered in editing the September JOURNAL of the Association.

Mr. George A. King presented, in writing, the following proposed amendment to the Constitution of the Association, and, by unanimous vote, it was recommended for adoption at the December meeting of this Association.

Strike out the whole of Section 2 of Article III, and make it to read as follows:

Sect. 2. The annual dues shall be —

For Members,	$5.00
For Associates,	25.00

Voted, that Mr. Henry A. Symonds be and hereby is appointed Editor of the JOURNAL of the Association, to fill the vacancy caused by the death of Editor William S. Johnson.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association, December 12, 1917, at headquarters, Tremont Temple, Boston, Mass.

Present: President Caleb Mills Saville, and members Carleton E. Davis, Samuel E. Killam, Henry V. Macksey, Frank J. Gifford, Lewis M. Bancroft, George A. King, and Willard Kent.

Four applications were received, two for active, viz., Frederic E. Beck, engineer, Consolidated Water Co., of Utica, N. Y.; John Y. Lavery, city engineer, Summit, N. J.; and two for associate membership, viz., Donaldson Iron Company, Emaus, Lehigh Co., Pa., and Hammond Process Company, Boston, Mass., and they were by unanimous vote recommended therefor.

The report of the special committee, appointed at the last meeting of the Executive Committee, " To consider the finances of the

Association and to make recommendations as to future methods of handling same, " was read, and it was unanimously *voted* that the report be accepted and that the chairman of the committee, Mr. Leonard Metcalf, be requested to present the same at the meeting of the Association this day. It was further voted that the thanks of the Executive Committee be given to Mr. Metcalf in expression of its appreciation of the valuable time and labor expended on the report.

The salary of the Editor was by vote fixed at three hundred dollars per annum, and that of the Advertising Agent at one hundred dollars and ten per cent. on new advertisements.

Requests that they be placed on the free mailing list of the JOURNAL of the Association were received from the Librarian of the University of Missouri and from the Public Service Commission of New Hampshire, whereupon it was *voted*, that the first request be referred to the Editor and that the second be laid on the table.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

JOURNAL

OF THE

New England Water Works Association.

VOLUME XXXI.

1917.

PUBLISHED BY
THE NEW ENGLAND WATER WORKS ASSOCIATION
715 TREMONT TEMPLE, BOSTON, MASS.

The four numbers composing this volume have been separately copyrighted in 1917 by the New England Water Works Association.

The Fort Hill Press
SAMUEL USHER
BOSTON

INDEX.

Accounting.
Some advantages of a classified cash book. ALBERT L. SAWYER. 54, March.
Water works accounting. EDWIN L. PRIDE. 63, March.
Addresses.
Mr. JAMES P. BERRY. 526, Sept.
Hon. CHARLES HOPKINS CLARK. 519, Sept.
Mr. CHARLES H. EGLEE. 127, March.
Hon. CHARLES E. GROSS. 522, Sept.
Hon. F. A. HAGARTY. 517, Sept.
Mr. FRANK G. MACOMBER, 528, Sept.
President CALEB M. SAVILLE. 152, March.
President CALEB M. SAVILLE (at Convention). 545, Dec.
President WILLIAM F. SULLIVAN. 144, March.

Batchelder, George W. Some experiences with a trenching machine. 486, Sept.
Brainard, Frank. Hartford distribution system. 581, Dec.
Breaks in water mains. S. E. KILLAM. 268, June.

Coagulant. The application of coagulant intermittently in excess amounts at Springfield, Mass. ELBERT E. LOCKRIDGE. 48, March.
Color. On the nature of color in water. THORNDIKE SAVILLE. 78, March.

Dams.
The Construction of Nepaug Dam. H. W. GRISWOLD. 603, Dec.
The design of the diversion conduit and waste works of Richards Corner dam at New Hartford, Conn. R. E. WISE. 595, Dec.
Grouting of the rock foundations of the dams of the additional water supply of the city of Hartford. J. E. GARRETT. 609, Dec.

Eaton, Harvey D. The extension of the water district idea in Maine. 196, June.
Electrolysis. Troubles caused thereby and remedies which may be applied. ALBERT F. GANZ. 280, June.

Filtration.
Care and operation of mechanical rapid sand filtration plant. JOHN W. GAITENBY. 619, Dec.
The first slow sand filters in the state of Maine. HENRY RICHARDS. 216, June.
Rapid sand filtration. GEORGE A. JOHNSON. 390, Sept.
Mechanical filter bottoms and strainer systems. ROBERT SPURR WESTON. 474, Sept.
Fire Protection. Report of committee on grading water works for fire protection. 6, March.
Forestry. Forestry in relation to public water supplies. Prof. J. W. TOUMEY. 247, June.

Gaitenby, John W. Care and operation of mechanical rapid sand filtration plant. 619, Dec.
Ganz, Albert F. Electrolysis — troubles caused thereby and remedies which may be applied. 280, June.
Garrett, J. E. Grouting of the rock foundations of the dams of the additional water supply of the city of Hartford. 609, Dec.
Governmental Regulation.
Public service regulation. W. D. WORTHEN. 163, June.
The regulation of private water companies in New York City. DELOS F. WILCOX. 550, Dec.
Griswold, H. W. The construction of Nepaug dam. 603, Dec.

Hartford distribution system. FRANK BRAINARD. 581, Dec.
Hartford water works — past and present. W. E. JOHNSON. 575, Dec.
Horne, H. W. Engineering on the additional water supply for the city of Hartford. 588, Dec.
Howard, Charles D. Some problems of water supply sanitation in New Hampshire. 237, June.

Jackson, J. Frederick. Some aspects of stream pollution in Connecticut. 627, Dec.
Johnson, George A. Rapid sand filtration. 390, Sept.
Johnson, W. E. Hartford water works — past and present. 575, Dec.

Killam, Samuel E.
Breaks in water mains. 268, June.
The result of the use of meters in the Metropolitan water district, Boston. 495, Sept.

Lockridge, Elbert E. The application of coagulant intermittently in excess amounts at Springfield, Mass. 48, March.

Meters. The result of the use of meters in the Metropolitan water district, Boston. SAMUEL E. KILLAM. 495, Sept.
Moulton, David E. The water supply of Portland, Me. 199, June.

New England Water Works Association.
Address by President Saville. 152, March.
Address of President Sullivan. 144, March.
Appointment of committee on award of Dexter Brackett Memorial. 3, March.
Election of officers. 151, March.
Proceedings:
Dec. 13, 1916. 124, March.
Annual meeting, Jan. 13, 1917. 129, March.
Feb. 14. 155, March.
March 14. 312, June.
June 13. 642, Dec.
Sept. 11, 12, 13, 14 (Convention). 512, Sept.
Nov. 14. 644, Dec.
Dec. 12. 656, Dec.
Executive committee.
Dec. 13, 1916. 158, March.
Jan. 10, 1917. 159, March.
Jan. 29. 160 March.
Feb. 14. 160 March.
March 7. 315, June.
March 14. 316, June.
June 13. 671, Dec.
Sept. 11. 541, Sept.
Sept. 13. 542, Sept.
Nov. 14. 671, Dec.
Dec. 12. 673, Dec.
Reports:
Committee on grading water works with reference to their value for fire protection. 6, March.
Committee on Dexter Brackett Memorial. 1, March; 541, Sept. Presentation of medal. 648, Dec.
Committee on water consumption. 481, Sept.
Committee on exhibits. 650, Dec.
Committee on finance. 658, Dec.
Committee on service pipe. 323, Sept.
Auditing Committee. 144, March.
Editor. 140, March.
Executive Committee. 132, March.
Secretary. 136, March.
Treasurer. 138, March.

Obituary. Albert Seward Glover. 319, June.
Operating Problems. Some operating problems of a small water department. HOMER R. TURNER. 633, Dec.

Pipe.
Breaks in water mains. S. E. KILLAM. 268, June.
Electrolysis — troubles and remedies. ALBERT F. GANZ. 280, June.
Universal pipe. JOHN H. WALSH. 490, Sept.
Portland, Me. The water supply of Portland, Me. DAVID E. MOULTON. 199, June.
Portrait.
Albert S. Glover. 320, June.
Caleb Saville. Frontispiece, March.
Pride, Edwin L. Water-works accounting. 63, March.

Richards, Henry. The first slow sand filter in the state of Maine. 216, June.

Saville, Thorndike. On the nature of color in water. 78, March.
Sawyer, Albert L. Some advantages of a classified cash book. 54, March.
Stream Pollution. Some aspects of stream pollution in Connecticut. J. FREDERICK JACKSON. 627, Dec.

Toumey, Prof. J. W. Forestry in relation to public water supplies. 247, June.
Trenching Machine. Some experiences with a trenching machine. GEORGE W. BATCHELDER. 486, Sept.
Turner, Homer R. Some operating problems of a small water department. 633, Dec.

Universal pipe. Experiences with universal cast-iron pipe. JOHN H. WALSH. 490, Sept.

Wadsworth, Lewis L. The water supply of Madison, Anson, and Emden, Me. 207, June.
Walsh, John H. Experiences with universal cast-iron pipe. 490, Sept.
Water Purification.
Application of coagulant intermittently in excess amounts at Springfield, Mass. ELBERT E. LOCKRIDGE. 48, March.
First slow sand filters in Maine. HENRY RICHARDS. 216, June.
Mechanical filter bottoms and strainer systems. ROBERT SPURR WESTON. 474, Sept.
Rapid sand filtration. GEORGE A. JOHNSON. 390, Sept.

Water Supply.
Hartford distribution system. FRANK BRAINARD. 581, Dec.
Hartford water works — past and present. W. E. JOHNSON. 575, Dec.
Madison, Anson, and Emden, Me. LEWIS L. WADSWORTH. 207, June.
Portland, Me. DAVID E. MOULTON. 199, June.
Weston, Robert Spurr. Mechanical filter bottoms and strainer systems. 474, Sept.
Wilcox, Delos F. The regulation of private water companies in New York City. 550, Dec.
Wise, R. E. The design of the diversion conduit and waste works of the Richards Corner dam at New Hartford, Conn. 595, Dec.
Worthen, W. D. Public service regulation. 163, June.

WILLARD KENT, *Sec'y*,

715 Tremont Temple, Boston, Mass.

$ .75

Dear Sir: Enclosed please find 1.50 in payment of charge for Certificate

2.25

of Membership in the N. E. W. W. Association ($1.50), and Membership Button ($ .75), which please mail me and oblige

Yours truly,

INDEX OF ADVERTISERS.

	PAGE
Ashton Valve Co.	xv
Buffalo Meter Co.	ix
Builders Iron Foundry	xi
Chadwick-Boston Lead Co.	xxiv
Chapman Valve M'f'g Co.	xviii
Clark, H. W. Co.	xii
Coffin Valve Co.	xxv
Conard, Wm. R.	xii
Dixon, Jos., Crucible Co.	xii
Donaldson Iron Co.	xxi
Eddy Valve Co.	xx
Engineering News-Record	xxviii
Fox, John & Co.	xxiii
Hammond Process Co.	xxx
Hays M'f'g Co.	xiii
Hersey M'f'g Co.	iv
Hill, Nicholas S., Jr., & S. F. Ferguson	xii
Houdlette, Fred A., & Son	xii
Lead Lined Iron Pipe Co.	xxiii
Leadite Co.	xxvi
Lock Joint Pipe Co.	xxvii
Ludlow Valve M'f'g Co.	xvii
Metcalf & Eddy	xii
Michigan Pipe Co.	Back cover
Mueller, H. M'f'g Co.	xiv
National Meter Co.	ii, iii
National Water Main Cleaning Co.	xv
Neptune Meter Co.	vi
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xix
Pitometer Company	x
Pittsburgh Meter Co.	vii
Rensselaer Valve Co.	xxix
Ross Valve M'f'g Co.	xv
Smith, The A. P. M'f'g Co.	xxiii
Smith, B. F. & Co.	xii
Thomson Meter Co.	v
Union Water Meter Co.	x
U. S. Cast Iron Pipe and Foundry Co.	xxii
Warren Foundry and Machine Co.	xix
Wood, R. D. & Co.	xvi
Worthington Pump and Machinery Corp'n	viii

(*Classified index on page xvii.*)

Water Meters

FOR ALL WATER WORKS SERVICE

All Sizes, 5-8 to 60 inches

CROWN

EMPIRE

NASH

GEM

PREMIER

With the only reliable straight-reading register in the market

National Meter Company

84-86 CHAMBERS STREET

NEW YORK CITY

BOSTON 159 Franklin St. | CHICAGO 1223 Wabash Ave. | PITTSBURG 4 Smithfield St. | LOS ANGELES 411 So. Main St.

CINCINNATI 10 West Third St. | SAN FRANCISCO 681 Market St.

The NASH
GAS ENGINE and TRIPLEX PUMP

FOR
Town and Village Water Works and Pumping Service Generally

CAN BE ADAPTED FOR EITHER GAS OR GASOLENE

National Meter Company
84-86 CHAMBERS STREET, NEW YORK

BOSTON: 159 Franklin Street
PITTSBURG: 4 Smithfield Street
CINCINNATI: 10 West Third Street
CHICAGO: 1223 Wabash Ave.
SAN FRANCISCO: 681 Market Street
LOS ANGELES: 411 South Main Street

APPROVAL

HERSEY DETECTOR METER

The Hersey Detector Meter has been accepted for eleven years in 3", 4", 6", 8", 10" and 12" sizes without any restrictions or conditions of any kind by every Insurance Company, Stock and Mutual, doing business in the United States, and by the Water Departments and Water Companies in more than 500 Cities and Towns for use on over 3,000 Fire Services protecting nearly $2,000,000,000. worth of Insured Property.

HERSEY MANUFACTURING COMPANY

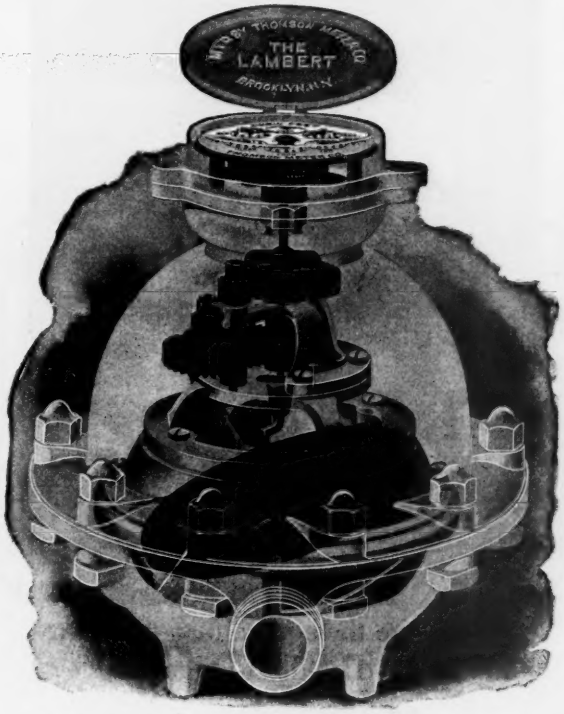
BOSTON	COLUMBUS, O.	SAN FRANCISCO
NEW YORK	PHILADELPHIA	LOS ANGELES
CHICAGO	ATLANTA	PORTLAND, ORE.

ACCURACY, LONG LIFE,

Avoidance of Repairs

Are the Requisites of the Perfect Water Meter and are the Principal Features of the

"LAMBERT."

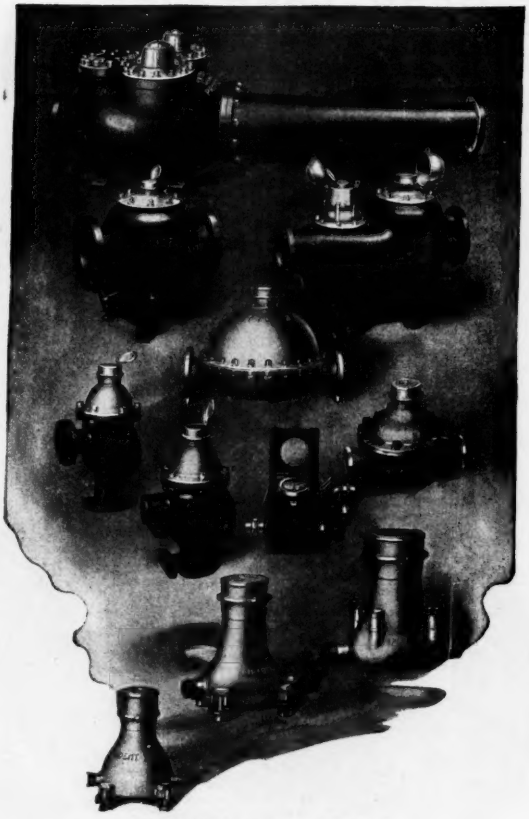


Our unbreakable disk-piston, reinforced with an internal steel plate, can be found only in the **LAMBERT METER.**

The growing popularity of the water-meter system is attributed by many to the inherent excellence of the **"LAMBERT"** meter. Where **"LAMBERT"** meters are selected, success is assured.

THOMSON METER CO.

100-110 BRIDGE ST.
BROOKLYN, N. Y.



A Trident for Every Service!

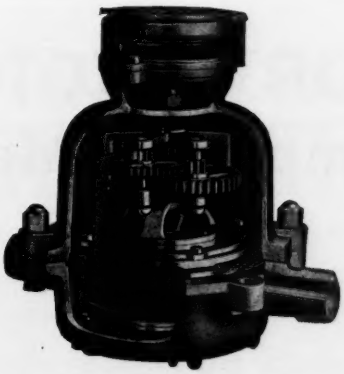
WHY are there more than a million and a half TRIDENTS in service?

There is only one reason,—TRIDENTS are more continuously accurate, more durable, more economically maintained. They are the *best* meters. Don't stint quality — you need the best for *your* services!

NEPTUNE METER COMPANY

50 EAST 42d ST., NEW YORK CITY

Atlanta **Boston** **Chicago**
Cincinnati **Denver** **Portland**
San Francisco **Los Angeles** **Seattle**



"KEYSTONE" WATER METER

NEW YORK CHICAGO

Keystone and Eureka

Water Meters

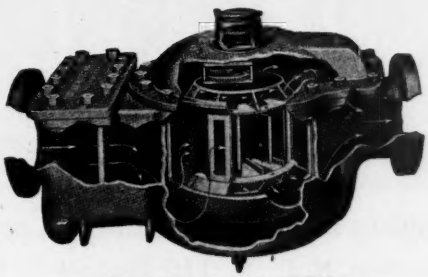
Pittsburgh Meter Co.

East Pittsburgh, Pa.

LOS ANGELES SEATTLE

COLUMBIA, S. C.

KANSAS CITY

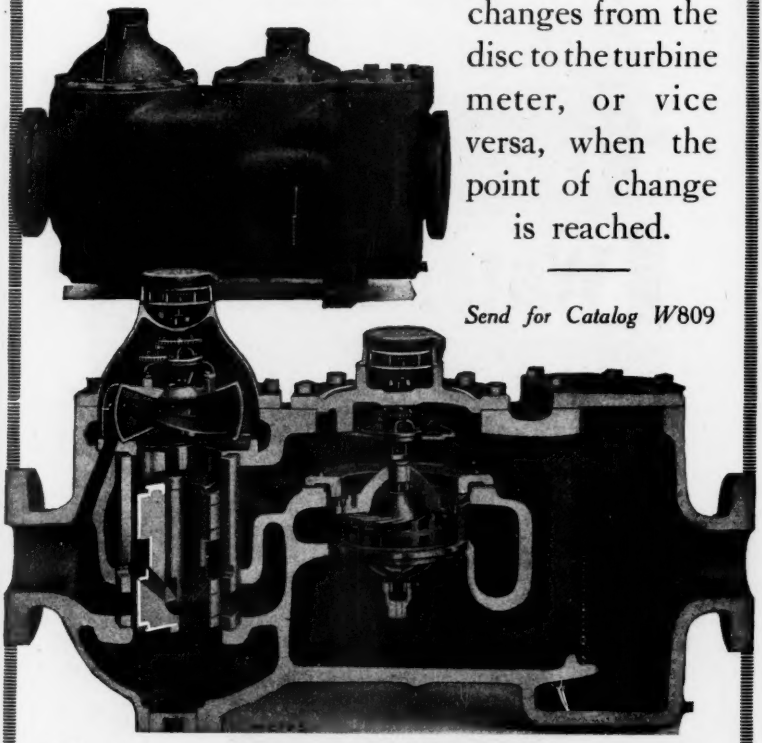


"EUREKA" WATER METER

WORTHINGTON
Compound Meter

The design of this meter is such that the action of the plunger valve (both up and down) is always sharp and positive; "no breaking point" in the registration where the flow changes from the disc to the turbine meter, or vice versa, when the point of change is reached.

Send for Catalog W809



Worthington Pump & Machinery Corporation

Works: Harrison, N. J. **115 Broadway, New York**

AMERICAN AND NIAGARA
WATER METERS

AMERICAN NIAGARA

ACCESSIBLE

Our meter may be opened at the bolted flange without disconnecting it from the pipe, each intermediate gear may then be lifted from its bearing and the measuring chamber removed from its seat. No other meter is so simple and accessible for inspection, cleaning or repairing. Sample meter sent to any water works on trial.

BUFFALO METER CO.

2917 MAIN ST. EST. 1892 BUFFALO, N.Y.

UNION ROTARY, COLUMBIA, DISC and NILO (Velocity) WATER METERS

Water Pressure Regulators
Waste Stops and Corporations

UNION WATER METER COMPANY
WORCESTER, MASSACHUSETTS

WATER WORKS SUPERINTENDENTS!

Is your per capita consumption too high?

Do you account for less than 85% of your pumpage?

Are you receiving full revenue from your manufacturing consumers?

If any of these problems confront you, write us at once, without obligation, and let us tell you about our PITOMETER SURVEYS.

THE PITOMETER COMPANY
25 Elm Street (N. Y. Edison Building)
NEW YORK CITY, N. Y.

ODD SHAPED CASTINGS A SPECIALTY

We are well equipped to make water pipe castings of unusual shapes and sizes, having had a great deal of experience in contract foundry work for many large, well-known companies and for the United States Government.

Globe Special Castings permit the combination of a number of branches in a single casting, avoid useless accumulations of metal, and offer the greatest possible resistance to bursting strains.

Catalogue K sent on request.

THE VENTURI METER

Measures hot and cold water, sewage, brine, chemical solutions, oil, gas, air and steam. Bulletin 84-W sent on request.

BUILDERS IRON FOUNDRY

PROVIDENCE RHODE ISLAND

Metcalf & Eddy

14 Beacon Street, Boston, Mass. — Harris Trust Building, Chicago, Ill.

WATER SUPPLY AND SEWERAGE

Design — Construction
Supervision — Management
Reports — Valuations

NICHOLAS S. HILL, Jr., and S. F. FERGUSON

Consulting Engineers, Water Supply and Sewage Disposal. Evaluations and Reports. Laboratory for Analysis of Water and Sewage and for Testing Cement, Sand, Coal, and Metals. Steam and Hydraulic Power Plants.

100 William Street, New York

H. W. CLARK CO.

122 South Seventeenth St., Mattoon, Illinois, U.S.A.

BRANCH OFFICES
NEW YORK SAN FRANCISCO CHICAGO
MANUFACTURERS

The Clark Meter Box — Meter Testers, Service and Valve Boxes, Valve Housings, and most everything for the Water Department.

Send for catalogues, prices, etc.

New Members!

Order your certificate of membership and the Association button Now.

WILLIAM R. CONARD

Assoc. Amer. Soc. C. E. — Assoc. Mem. Amer. Soc. M. E.

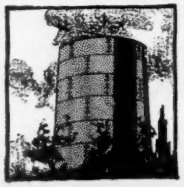
322 High St., Burlington, N. J.

Inspections and Tests of Materials

SOUTHERN OFFICE

Maison Blanche Bldg., New Orleans, La.

R. C. HUSTON, C.E., Special Representative



Standpipes
Water Tanks
Gas Holders

and all other metal surfaces need the protection of

DIXON'S Silica-Graphite PAINT

BOOKLET NO. 67-B

JOSEPH DIXON CRUCIBLE CO. Jersey City, N. J.

We Carry in BOSTON STOCK for Immediate Shipment

CAST IRON BELL AND SPIGOT WATER PIPE AND FITTINGS
FLANGED PIPE in full and short lengths
WROUGHT PIPE

FRED A. HOUDLETTE & SON

(Incorporated)

93 Broad Street, Boston, Mass.

Quotations furnished promptly for shipment from Foundry

C. D. Kirkpatrick — S. P. Gates

Established 1878

B. F. SMITH & CO.

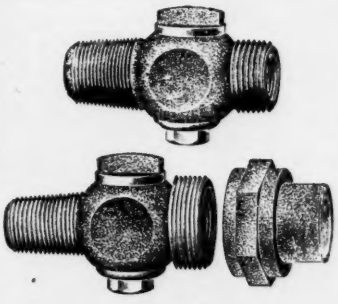
Incorporated

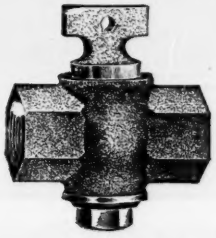
Artesian and Driven Wells, Foundation Boring

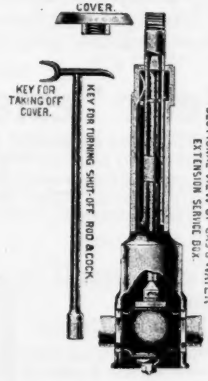
Engineers and Contractors for Municipal and Private Water Works

First National Bank Building
60 Federal Street — Boston, Mass.

"The Goods That Please"







Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

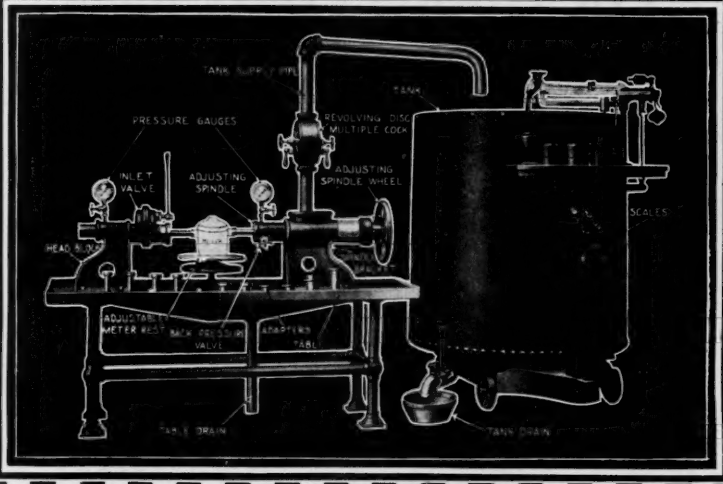
Let us send at our risk, on 30 days' trial, a

Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

Established 1869



The People Demand Increased Efficiency

You can make sure your Department gets full revenue for every gallon of water used—by seeing that all meters are regularly tested for accuracy—with the

Mueller Water Meter Tester

The Mueller will prove exactly what each meter does—will enable you to adjust each meter to absolute accuracy—will save more than its cost year after year. Used and endorsed by leading municipalities. The name Mueller guarantees both Quality and Service.

Detailed description and prices on request.

H. MUELLER MANUFACTURING CO., Decatur, Illinois
Phone Bell 153—Auto 2131

Water, Plumbing and Gas Brass Goods

New York City, 145 W. 30th St. — Phone, Madison Square 5397
San Francisco, 589 Mission St. — Phone Sutter 3577

© 1917 H MM Co

WATER
FILTERS
REGULATORS
& ENGINES

We make **Pressure Regulating Valves** for all purposes, steam or water.

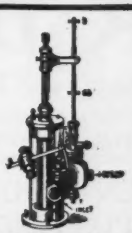
Our **Feed-Water Filter** will keep oil out of your boiler.

We can interest you if you use a condenser.

Water Engines for Pumping Organs

THE ROSS VALVE MFG. CO.

TROY, N. Y.



Standard for pumping church or parlor organs. Ask your organ builder for it or write us.

?

?

ENOUGH WATER?

If not, it is probably because of lack of carrying capacity of your mains. Consult us.

Illustrated booklet upon request

NATIONAL WATER MAIN CLEANING CO.

50 Church Street New York City

No. 20. Valve for Stationary Boilers.

They set the Pace

ASHTON POP VALVES and... STEAM GAGES

No. 74. Recording and Indicating Gage.

Superior in Quality of material and workmanship, and with greatest efficiency and durability, they challenge comparison with any others on the market. Send a trial order subject to approval ONLY IF SATISFACTORY, and thereby prove the claims made for them. HIGH GRADE GOODS OUR EXCLUSIVE SPECIALTY.

The ASHTON VALVE CO., 271 Franklin Street, BOSTON, MASS.

R. D. WOOD & CO.

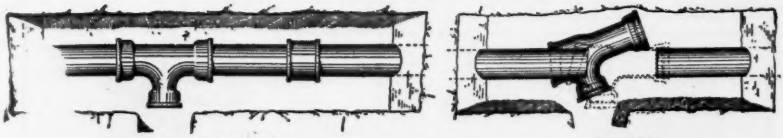
400 CHESTNUT STREET, PHILADELPHIA, PA.

Engineers, Iron Founders and Machinists

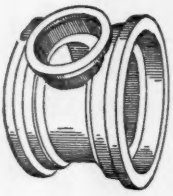
CENTRIFUGAL PUMPS
PUMPING ENGINES

Cast Iron Pipe

CUTTING-IN TEES



Old Way *Our Way*



Connections economically and easily made with one fitting. Saves sleeve, cuts, lead and unnecessary work and material.

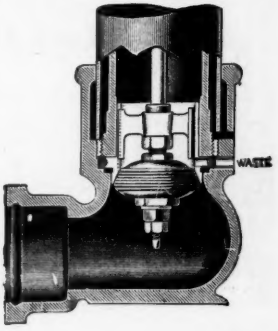
"Reduced Specials"

Cost of fittings reduced from 25% to 50%. Full strength. Deep bells. Convenient to handle. Sold by the piece.

Mathews Fire Hydrants

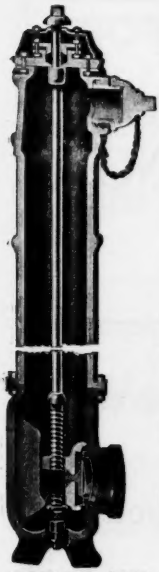
A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



Gate Valves

R. D. WOOD & CO. STANDARD
DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
AND MATERIAL



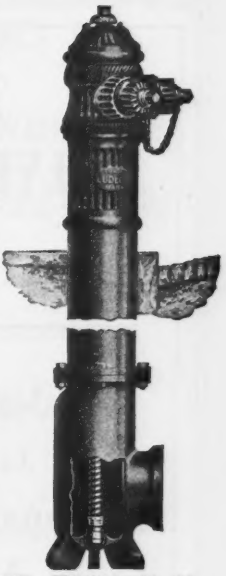
THE LUDLOW VALVE MFG. CO.

MANUFACTURERS OF

VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



DOUBLE AND SINGLE GATE VALVES,

ALSO CHECK VALVES,

FOOT VALVES.

FIRE HYDRANTS.

YARD, WASH, AND FLUSH HYDRANTS.

SEND FOR CIRCULARS.

OFFICE AND WORKS: FOOT OF ADAMS STREET, TROY, N. Y.

BRANCH OFFICES:

NEW YORK	PHILADELPHIA	BOSTON	PITTSBURGH	CHICAGO	KANSAS CITY
62 GOLD ST.	HARRISON BLDG.	OLIVER BLDG.	1ST NAT. BANK BLDG.	THE ROOKERY	VICTOR BLDG.

CLASSIFIED DIRECTORY OF ADVERTISEMENTS.

	PAGE.
ARTESIAN AND DRIVEN WELLS.	
B. F. Smith & Co.	xii
BRASS GOODS.	
Hays M'f'g Co.	xiii
H. Mueller Mfg. Co.	xiv
The A. P. Smith M'f'g Co.	xxiii
Union Water Meter Co.	x
CAST IRON PIPE AND SPECIALS.	
Builders Iron Foundry	xi
Donaldson Iron Co.	xxi
John Fox & Co.	xxiii
Houdelette, Fred A., & Son	xii
U. S. Cast Iron Pipe and Foundry Co.	xxii
Warren Foundry and Machine Co.	xix
R. D. Wood & Co.	xvi
CLEANING WATER MAINS.	
National Water Main Cleaning Co.	xv
ENGINEERS	
Hill, Nicholas S., Jr., & S. F. Ferguson	xii
Metcalf & Eddy	xii
FILTERS AND WATER SOFTENING PLANTS.	
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xix
Ross Valve M'f'g Co.	xv
FURNACES, ETC.	
H. Mueller Mfg. Co.	xiv
The A. P. Smith M'f'g Co.	xxiii
The Leadite Co.	xxvi

(Index continued on page xxv.)

THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

Gate Fire Hydrants

Corporation Cocks Curb Cocks

Anderson Couplings

Lead Pipe Connections

Trade

Mark

WRITE FOR OUR WATER-WORKS CATALOG

Main Office and Works
Indian Orchard, Mass.

BRANCH HOUSES

BOSTON, MASS. 141 High St.
NEW YORK CITY 180 Lafayette St.
PHILADELPHIA 1011 Filbert St.
CHICAGO 116 N. Jefferson St.

NORWOOD ENGINEERING CO.

FLORENCE, MASS.

MANUFACTURERS OF

"IMPROVED" WALKER FIRE HYDRANTS

ALSO THE OLD RELIABLE **"Holyoke" Gate Hydrant**

LICENSED MANUFACTURERS OF **The Vivian Rate Controller**

WRITE FOR CIRCULARS

We Want More Members

Help Us Get Them

Use Application on Last Page of Advertisements

Warren Foundry and Machine Co.

SALES OFFICES

11 BROADWAY, NEW YORK

201 DEVONSHIRE ST., BOSTON, MASS.

Telephone, Fort Hill 5951

CAST IRON PIPE

Bell and Spigot **Flanged Pipe**

Special Castings

Flexible Joint Pipe **Cylinders**

Water **Gas** **Sewers** **Culverts**

Works, Phillipsburg, N. J.

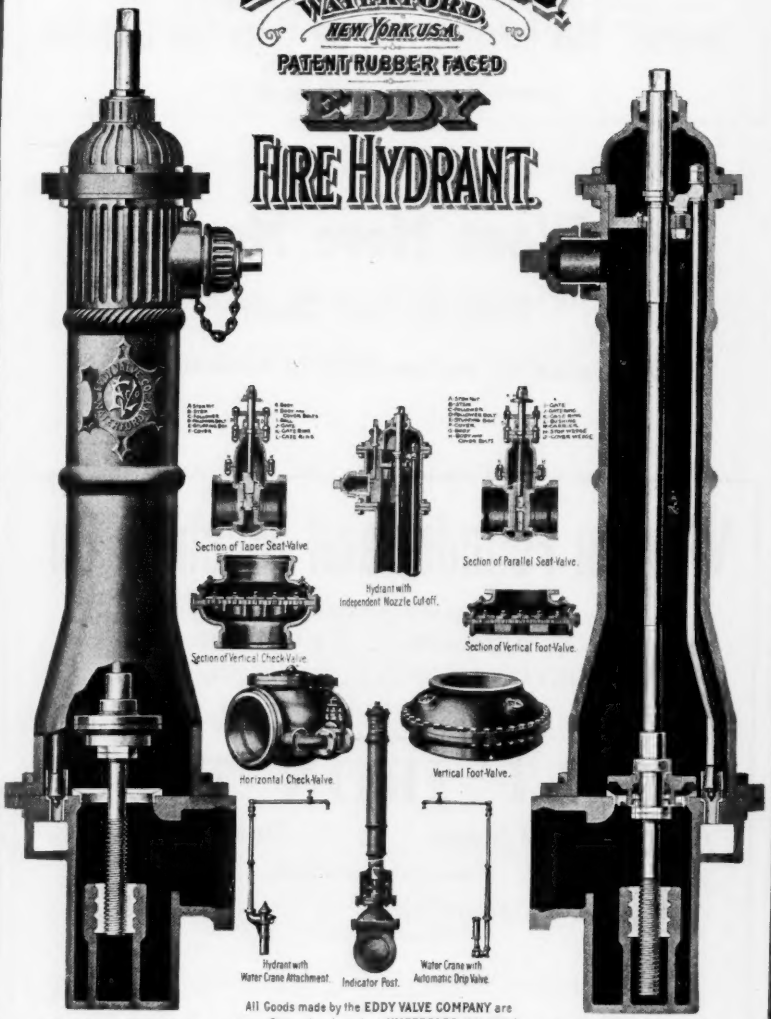
LARGE STOCK ENABLES US TO MAKE QUICK SHIPMENTS

EDDY VALVE CO.

WATERFORD, NEW YORK, U.S.A.

PATENT RUBBER FACED

EDDY FIRE HYDRANT



VALVE OPEN – DRIP CLOSED.

All Goods made by the EDDY VALVE COMPANY are manufactured exclusively at WATERFORD, N.Y., U.S.A.

VALVE CLOSED – DRIP OPEN.

GRAVITY AND PRESSURE FILTERS

HYPOCHLORITE STERILIZING APPARATUS

Over 350 Municipal Plants in Successful Operation

Total Daily Capacity 900,000,000 Gallons

THE NEW YORK CONTINENTAL JEWELL FILTRATION CO.

15 BROAD STREET NEW YORK
111 W. MONROE STREET CHICAGO
313 E. TENTH STREET KANSAS CITY
619 NEW BIRKS BLDG. MONTREAL

EMAUS PIPE FOUNDRY, DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND ..

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

JOHN D. ORMROD, President,
J. G. EBERLEIN,
Secretary and Treasurer.

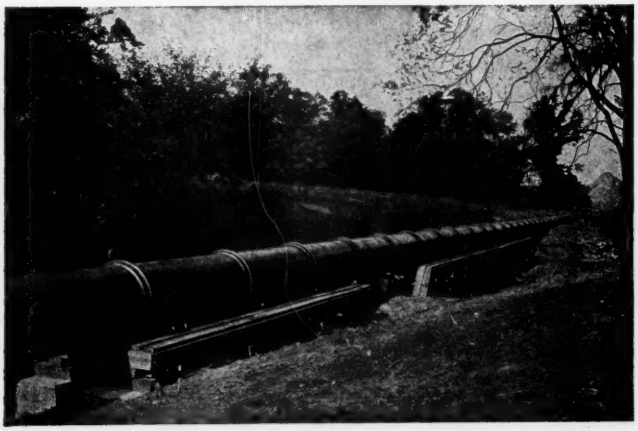
EMAUS,
LEHIGH COUNTY, PA.

CAST IRON PIPE

ALL REGULAR SIZES, 3 INCHES TO 84 INCHES

FOR WATER, GAS, SEWERS, DRAINS, ETC.

SEND FOR STANDARD SPECIFICATIONS



RAILROAD AND TURNPIKE CULVERTS

FLANGE PIPE AND FLANGE FITTINGS

HEAVY CASTINGS

AND THOSE MADE FROM ORIGINAL DESIGNS

United States Cast Iron Pipe and Foundry Company

SALES OFFICES

71 Broadway, New York City.
1421 Chestnut Street, Philadelphia, Pa.
Henry W. Oliver Building, Pittsburgh, Pa.
122 South Michigan Boulevard, Chicago, Ill.
520 Security Building, St. Louis, Mo.
American Trust Building, Birmingham, Ala.
799 Monadnock Building, San Francisco, Cal.

THE A. P. SMITH MANUFACTURING CO.

EAST ORANGE, N. J.

Manufacturers of

Tapping Machines, Fire Hydrants, Water Gates,
Economic Lead Furnaces,
Corporation and Curb Cocks, Brass and Aluminum Castings.
Also General Supplies for Water and Gas Works.

Write for Catalogue.

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON
WATER & GAS PIPES
FLANGE PIPE

Special Castings, Fire Hydrants, Valves
General Foundry and Machine Work
253 BROADWAY - - NEW YORK CITY
Postal Telegraph Building

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments
use
LEAD-LINED IRON and TIN-LINED PIPES
for their service connections

MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield ═══ Mass.

Chadwick-Boston Lead Co.

162 Congress St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable, but dangerous — **LEAD WOOL** may be employed to advantage. It makes perfectly tight joints to withstand the highest pressures, yet sufficiently elastic to admit of considerable sagging or settling of the pipe without causing the joint to leak. The difference in this respect, as compared with the poured joint, is notable.

NO FIRE — NO DANGER — NO TROUBLE.

Highest quality Lead Lined Iron Pipe and Fittings

Also **Pure Block-Tin Lined Iron Pipe and Fittings**

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder Pig Lead, White Lead and Red Lead

Coffin Valve Co.

BOSTON, MASS.

Manufacturers of Sluice Gates
Gate Valves
Check Valves
Flap Valves
Foot Valves
Fire Hydrants, etc.

SPECIAL ATTENTION PAID TO WATER-WORKS SUPPLIES FOR CITIES AND TOWNS

Send for Cuts and Prices of our
Type "B" Compression Hydrant and
Type "F" Gate Valves

Hydraulically and Electrically operated valves and sluice gates

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).

	PAGE.
GAS ENGINES.	
National Meter Co.	ii
GATES, VALVES, AND HYDRANTS.	
Ashton Valve Co.	xv
Chapman Valve M'f'g Co.	xviii
Coffin Valve Co.	xxv
Eddy Valve Co.	xx
John Fox & Co.	xxiii
Ludlow Valve M'f'g Co.	xvii
Norwood Engineering Co.	xix
Rensselaer Valve Co.	xxix
Ross Valve M'f'g Co.	xv
The A. P. Smith M'f'g Co.	xxiii
R. D. Wood & Co.	xvi
INSPECTION OF MATERIALS.	
Wm. R. Conard	xii
LEAD AND PIPE.	
Chadwick-Boston Lead Co.	xxiv
Lead Lined Iron Pipe Co.	xxiii
LEADITE.	
The Leadite Co.	xxvi
METERS.	
Buffalo Meter Co.	ix
Builders Iron Foundry	xi
Hersey M'f'g Co.	iv
National Meter Co.	ii
Neptune Meter Co.	vi
Pitometer Co.	x
Pittsburg Meter Co.	vii
Thomson Meter Co.	v
Union Water Meter Co.	x
Worthington Pump and Machinery Corp'n	viii

(*Index continued on page xxix.*)

Twelve Reasons Why

YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

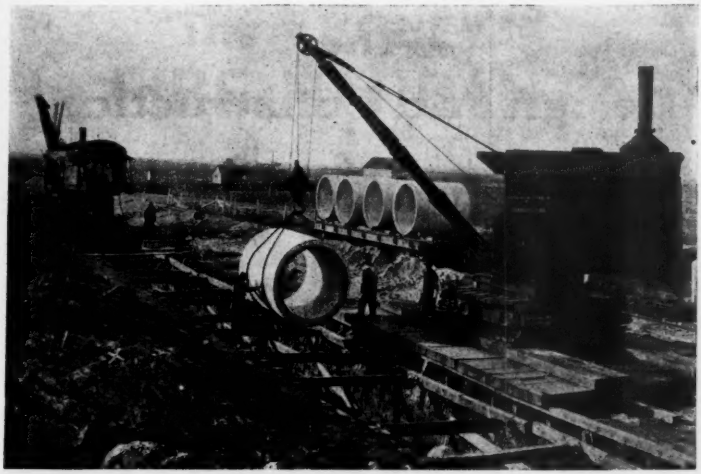
Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

WRITE FOR BOOKLET

THE LEADITE COMPANY, Inc.

LAND TITLE BUILDING PHILADELPHIA



Laying 66-inch Reinforced Concrete "Lock Joint" Pipe for the Greater Winnipeg Water District.

Length, 10 miles.

Heads, 45 to 90 feet.

All Pressure Pipes are provided with Copper Expansion Joints.

The Strongest and Most Permanent Water Pipe made.

We will gladly furnish you with estimates.

LOCK JOINT PIPE CO.

165 BROADWAY **NEW YORK CITY**

Factory, Ampere, N. J.

The Design and Construction of Water-Works Systems

and Novel Features in their Management are given careful attention by

Engineering News-Record

It also gives prominence to the following departments of a Water-Works System:

DAMS
AQUEDUCTS
PUMPING STATIONS
PIPE SYSTEMS
WATER TOWERS
FILTERS

SAMPLE COPIES FREE

Subscription Price, $5.00 a Year

ENGINEERING NEWS-RECORD

10TH AVE. AT 36TH STREET NEW YORK

The "COREY"
FIRE HYDRANT

MODERN
SUCCESSFUL
SIMPLE
DURABLE

SUPERIOR

RENSSELAER VALVES

ALL SIZES ALL PRESSURES

WATER, STEAM, GAS, OIL, ETC.

ELECTRICALLY OPERATED VALVES
Check Valves Air Valves
Indicator Posts Valve Boxes

CATALOGUE UPON APPLICATION

RENSSELAER VALVE CO., Troy, N. Y.

BRANCHES

NEW YORK, 50 Church PITTSBURG, 1704 Oliver Bldg.
CHICAGO, 1108-9 Monadnock Block SEATTLE, Arctic Bldg.

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Concluded*).

PAGE.

METER BOXES.
Clark, H. W. Co. . . . xii
Hersey M'f'g Co. . . . iv

OIL, GREASE, ETC.
Jos. Dixon Crucible Co. . . . xii

PIPE JOINTS.
The Leadite Co. . . . xxvi

PRESSURE REGULATORS.
H. Mueller Mfg. Co. . . . xiv
Ross Valve M'f'g Co. . . . xv
Union Water Meter Co. . . . x

PROTECTIVE COATINGS.
Hammond Process Co. . . . xxx

PUMPS AND PUMPING ENGINES.
Builders Iron Foundry . . . xi
National Meter Co. . . . iii
R. D. Wood & Co. . . . xvi

REINFORCED CONCRETE PIPE.
Lock Joint Pipe Co. . . . xxvii

TAPPING MACHINES.
Hays Mfg. Co. . . . xiii
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii

TOOLS AND SUPPLIES.
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Hays M'f'g Co . . . xiii
The Leadite Co. . . . xxvi

WOOD PIPE.
Michigan Pipe Co. . . . Back cover

HAMMOND PROCESS COMPANY

Manufacturers of

Mill Whites
Brick and Concrete Coaters
Wall Finishes

TRADE MARK FEROX REGISTERED U.S.PAT.OFF.

Asphaltum
Iron Oxide Paints for Steel Protection

Paints for all purposes

SALES OFFICE
7 WATER STREET
BOSTON, MASS.

FACTORY
22 KENT STREET
SOMERVILLE, MASS.

Patronize

the Advertisers of the

JOURNAL

New England Water Works Association,

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at.....

.....*being desirous of admission into the New England Water Works Association, hereby make application for* .....
(resident, non-resident or associate)

.....*membership.*

I am.....*years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed,.....

Address,.....

Dated,.....*191*

Resident members are those residing in New England; all others are non-resident.
Entrance fee is $5.00 for resident and $3.00 for non-resident members.
Annual dues are $4.00 for both resident and non-resident members.